

# Pharmaceuticals and other wastewater indicator compounds in two urban streams, Metropolitan Kansas City

**Principal Investigator: Don Wilkison**

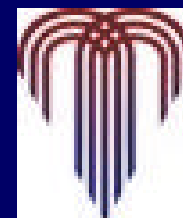
**Project team: Dan Armstrong, Eric Christensen,  
Shelley Severn, Dale Blevins**

**Analytical R&D: Steve Zaugg, Ed Furlong, Andy Carson**



American College of Toxicology  
21<sup>st</sup> Annual Meeting; San Diego, CA

Cooperator



**City of Kansas City, MO**

# Outline

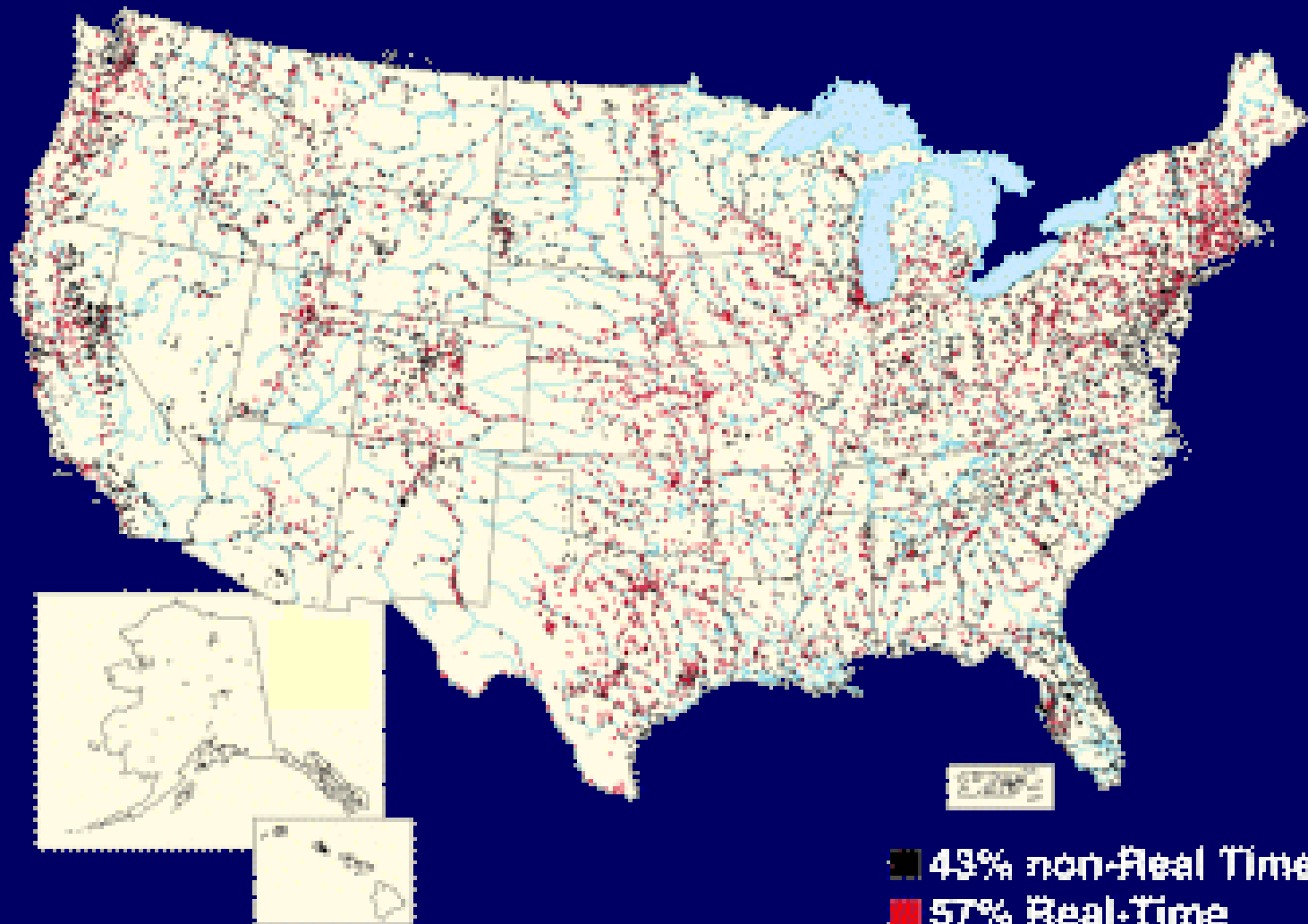
- Who is the USGS? What are we doing here?
- Study design and approach
- Conceptual model
- Apply some fuzzy math
- Engage in Punditry
- Summary/Overarching questions

# USGS Mission

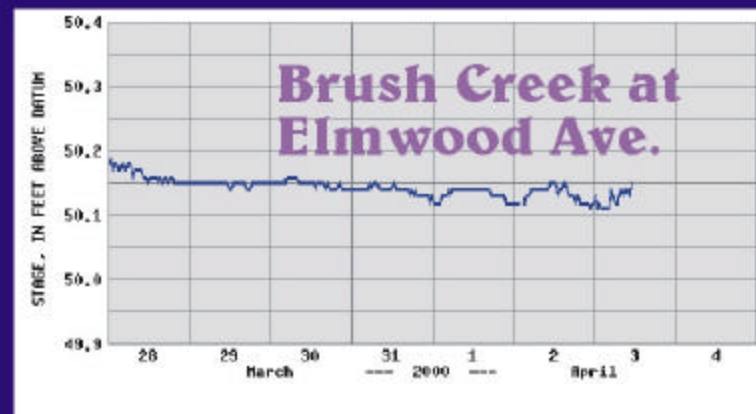
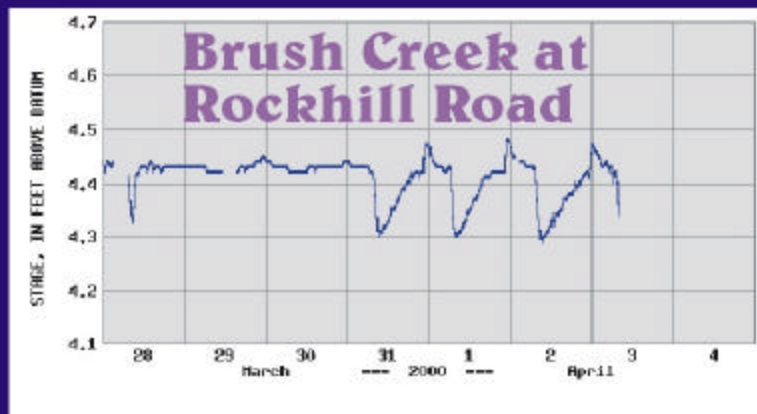
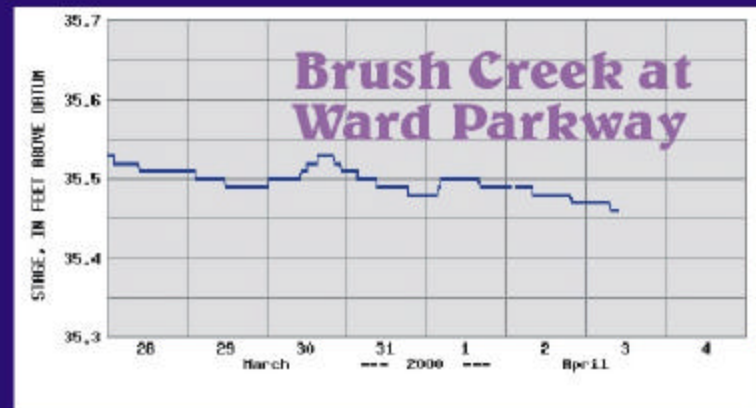
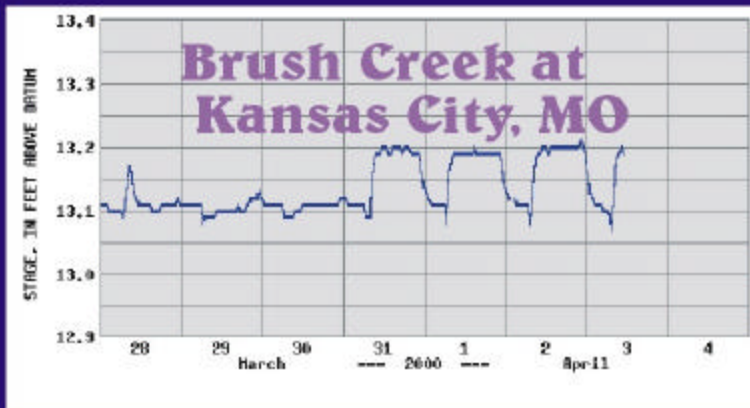
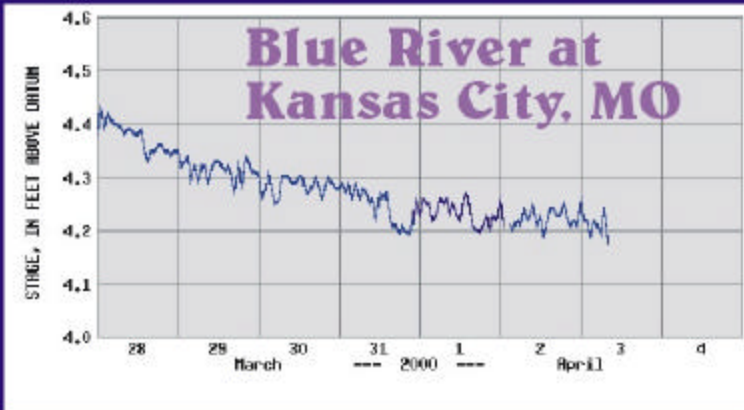
**The USGS serves the Nation by providing reliable scientific information to:**

- **describe and understand the Earth;**
- **minimize loss of life and property from natural disasters;**
- **manage water, biological, energy, and**
- **mineral resources; and**
- **enhance and protect our quality of life.**

# USGS Streamgaging Network



# Realtime Stream-flow data available at <http://water.usgs.gov>

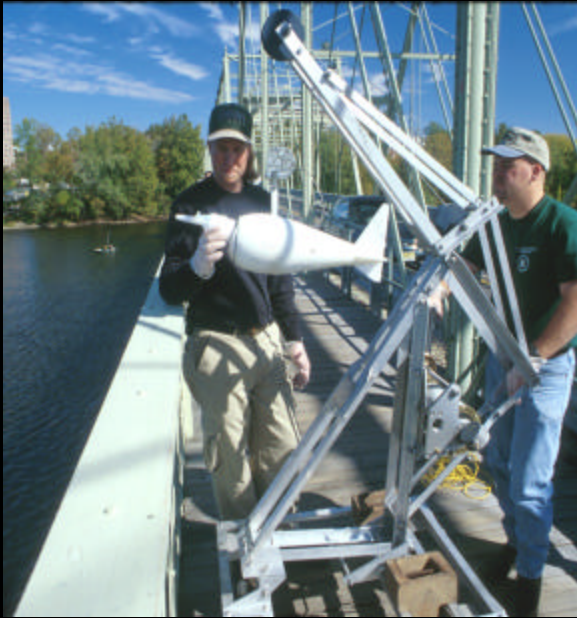


# Guiding Principles of the Streamgaging Network

- Many partners contribute funding
- All data are freely available
- USGS operates the network on behalf of all

# **Expanding Uses of Streamflow Information**

- **Resource Appraisal and allocation**
- **Design of Nation's water infrastructure**
- **Flood Hazard Planning and forecasting**
- **Reservoir Operations**
- **Water Quality Management**
- **Instream flows for habitat assessment**
- **Understanding changes in streamflow**
- **Recreational safety**



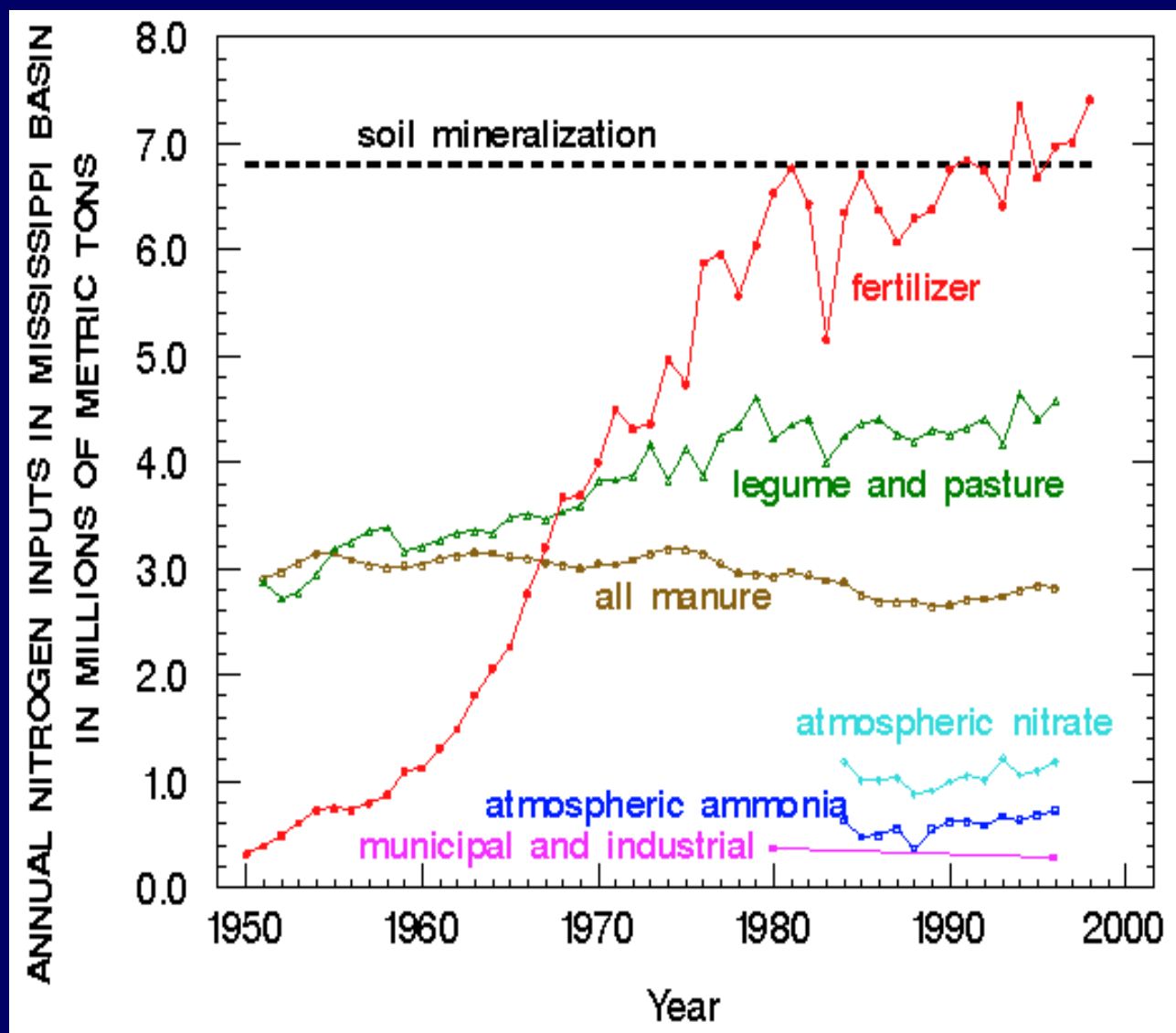
## Mississippi River Basin with Gulf of Mexico Hypoxia Zone



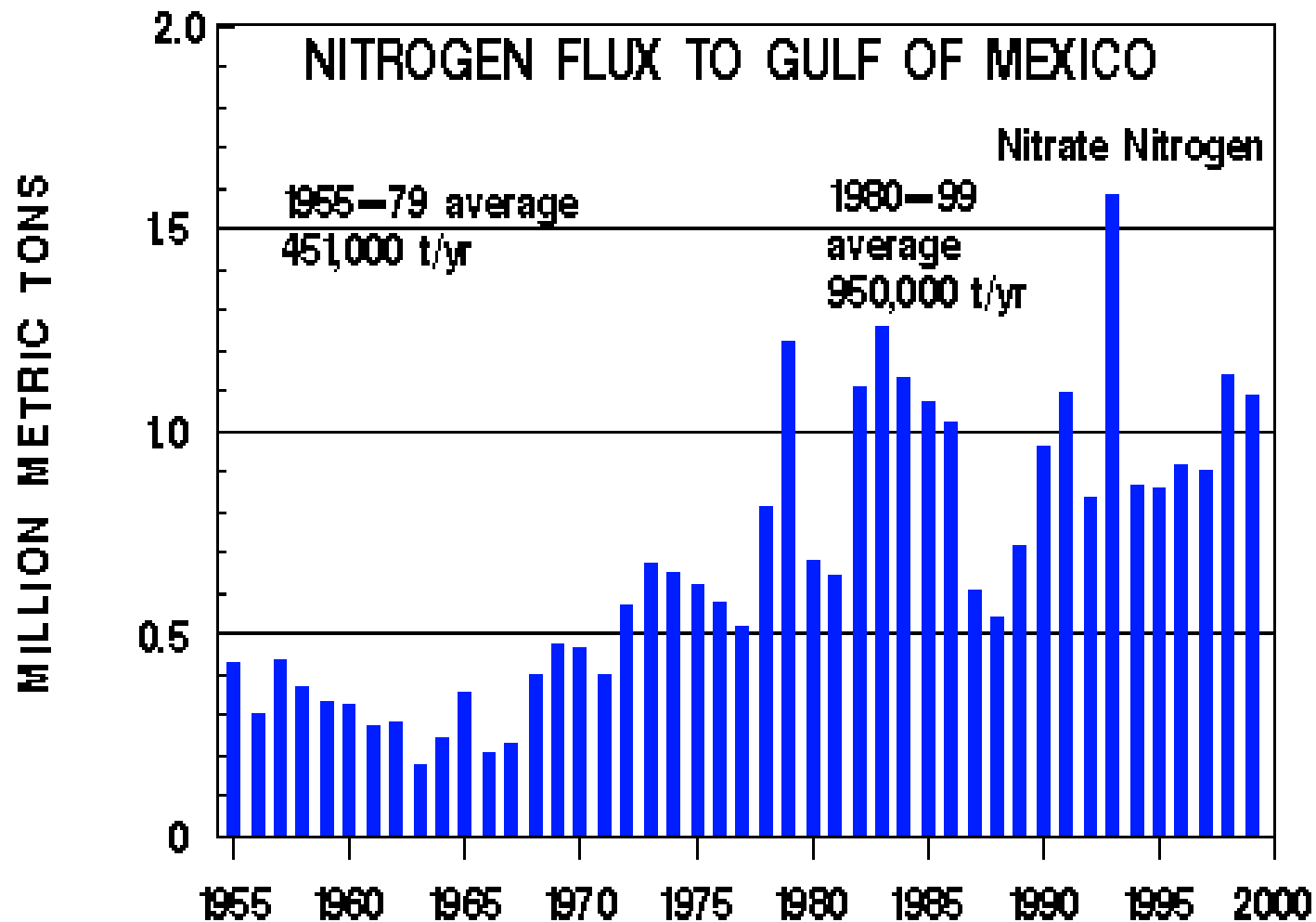
Hypoxia Area - July 23-29, 1997



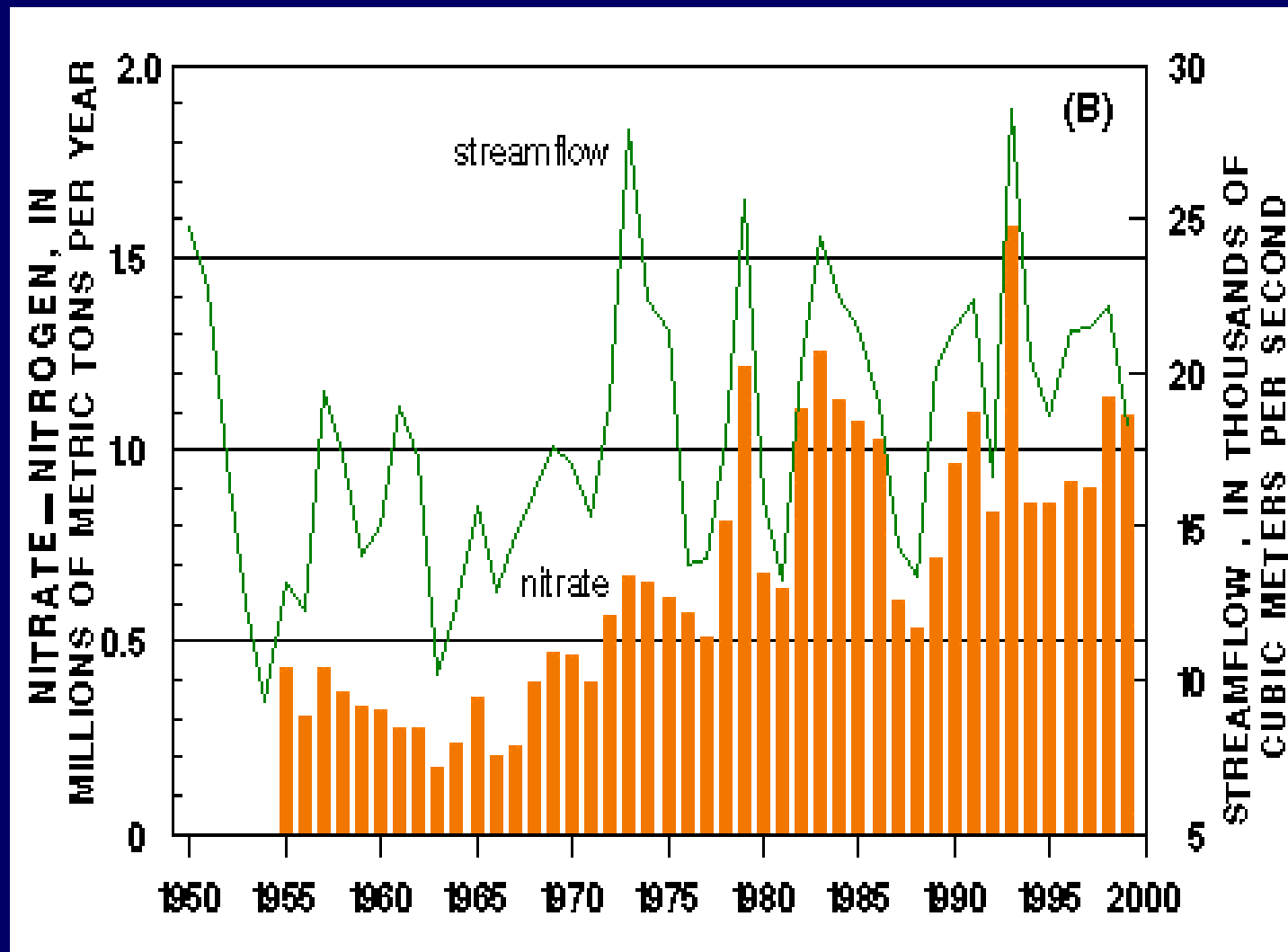
# Nitrogen Inputs to the Mississippi River Basin



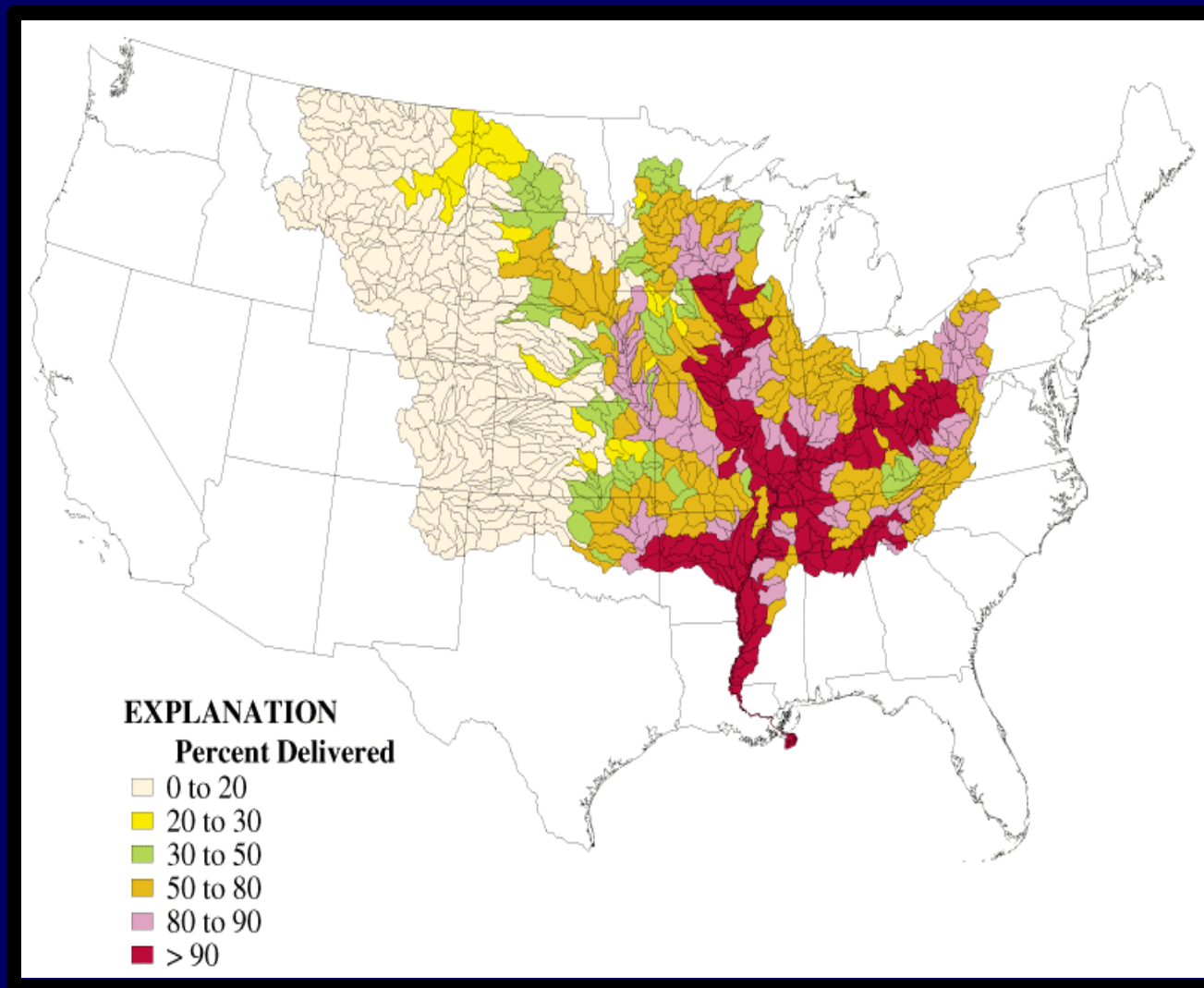
# Annual Nitrate Flux to Gulf of Mexico

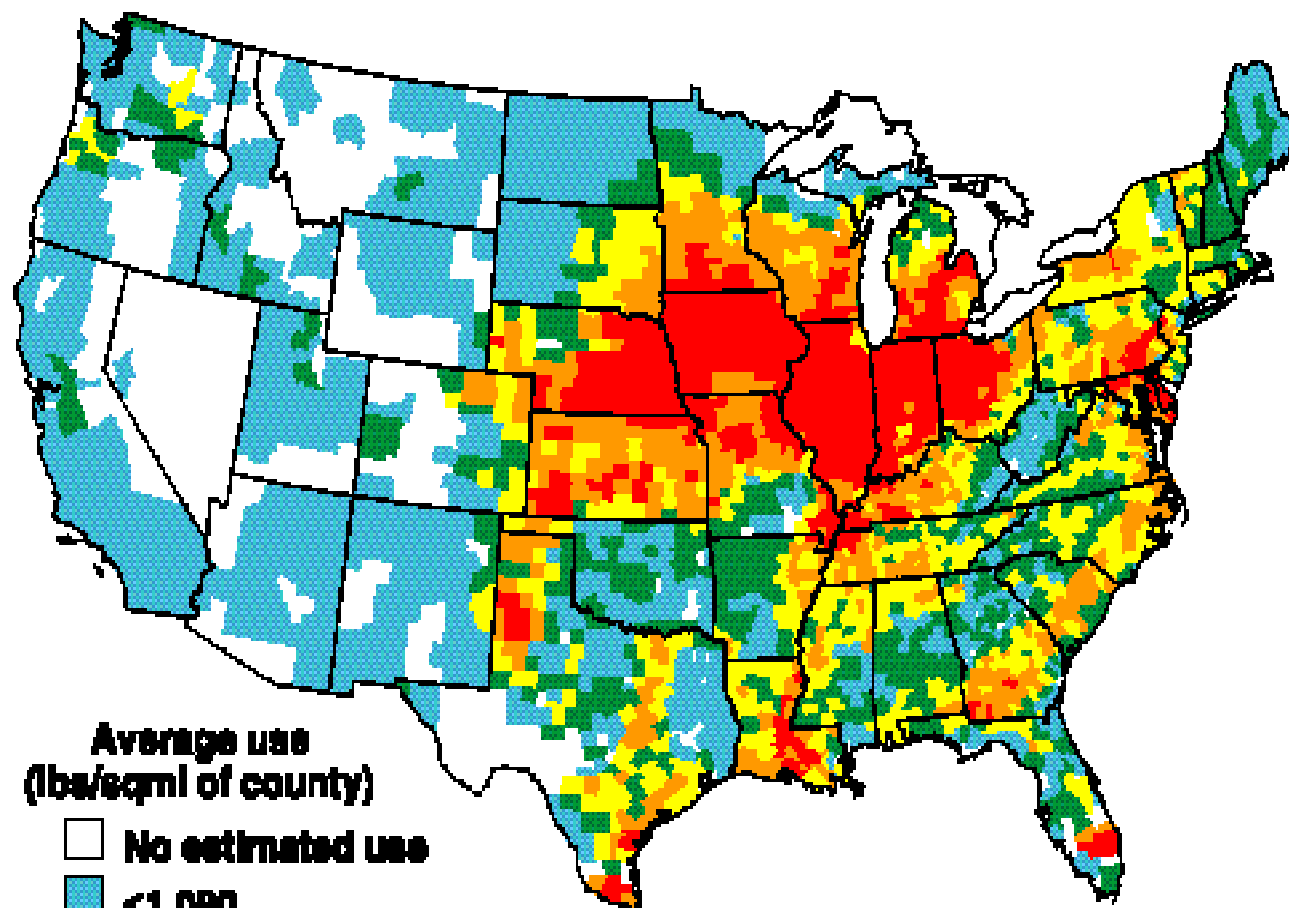


# Annual Nitrate Flux to Gulf of Mexico and Mean Annual Streamflow



# Percentage of the Nitrogen export from Interior Watersheds Delivered to the Gulf

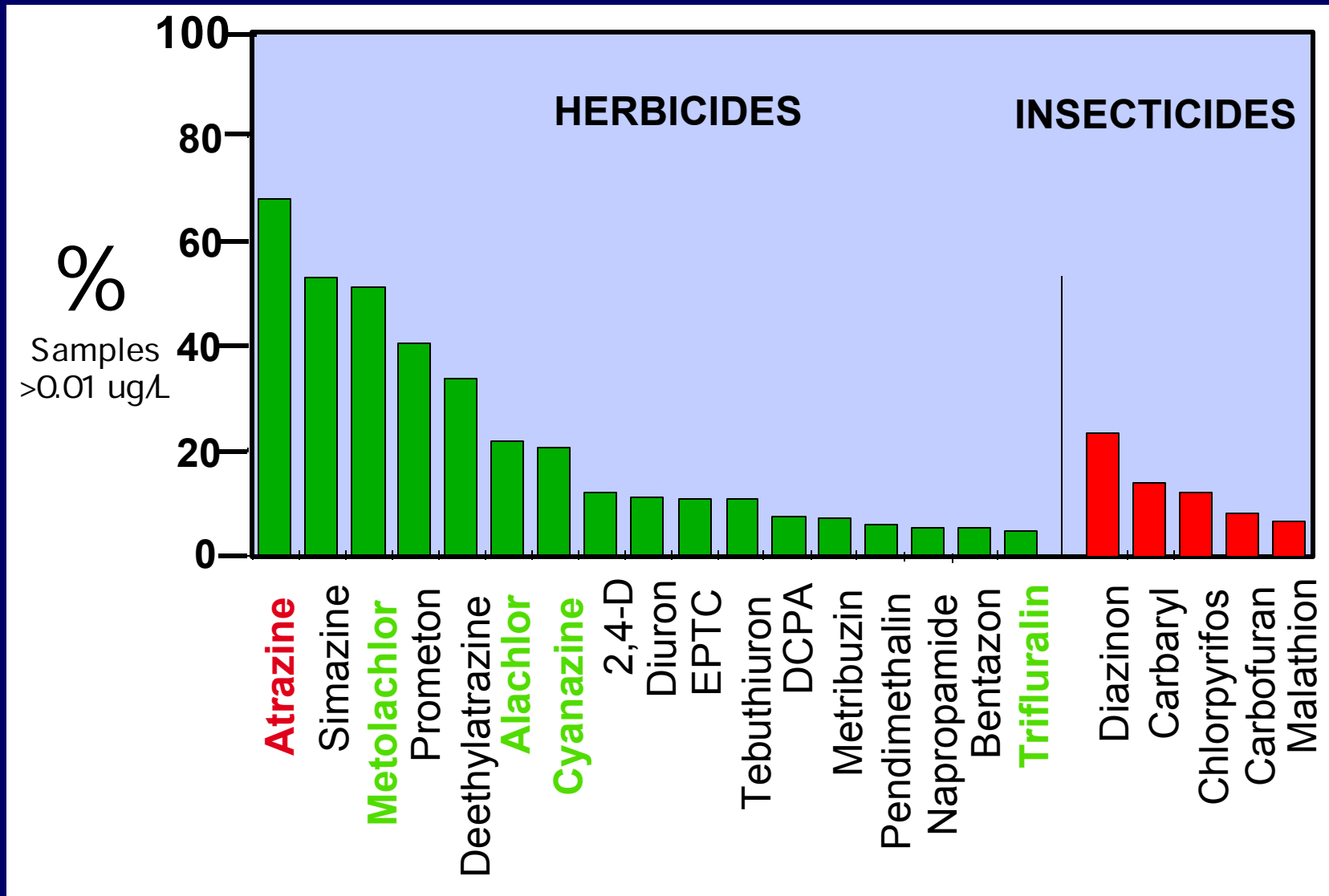




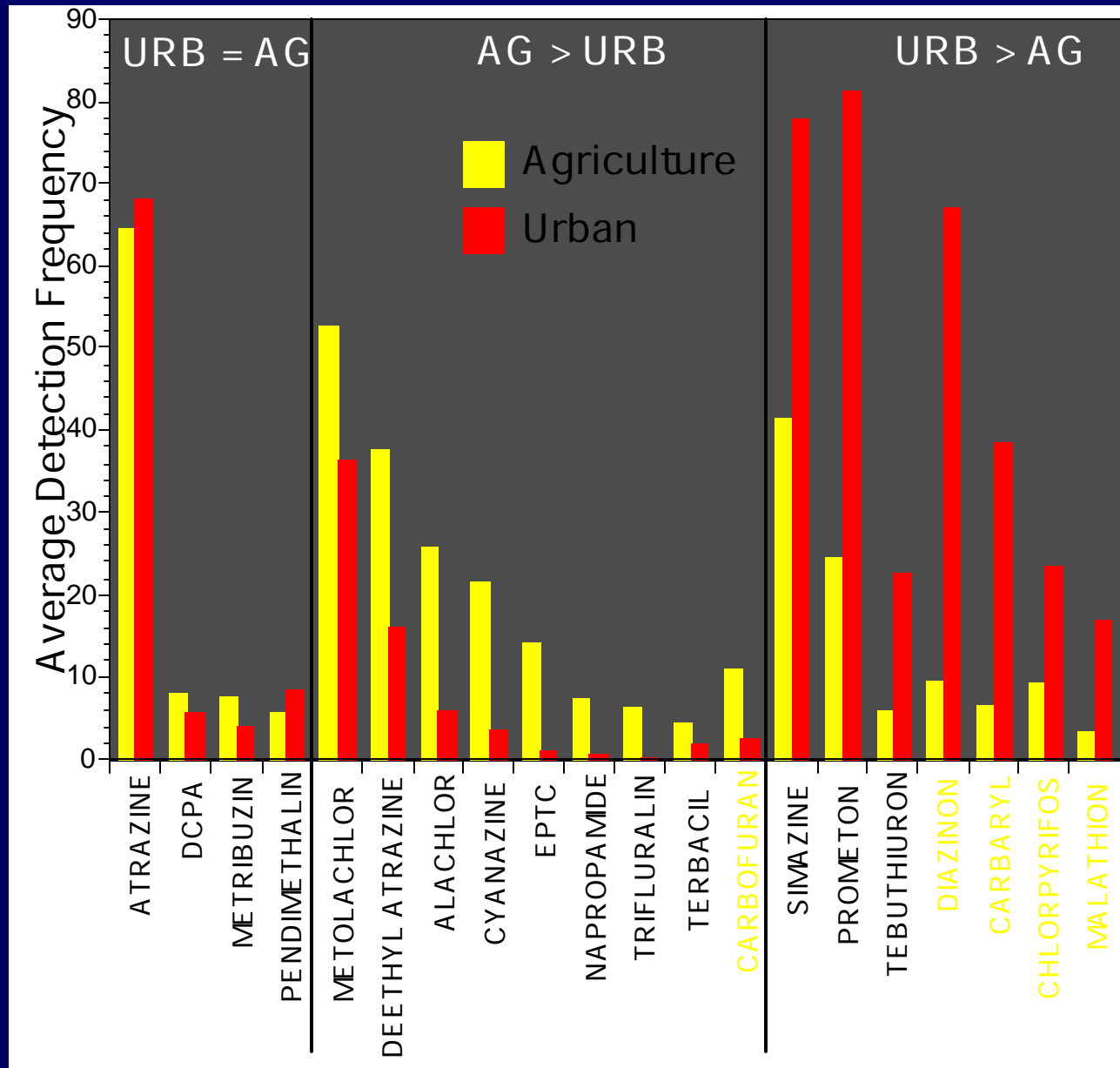
**Average use  
(lbs/acmi of county)**

- No estimated use
- <1.080
- 1.080 - 6.587
- 6.588 - 21.211
- 21.212 - 66.515
- ≥ 66.516

# National Overview of Pesticide Detection Frequencies in Streams

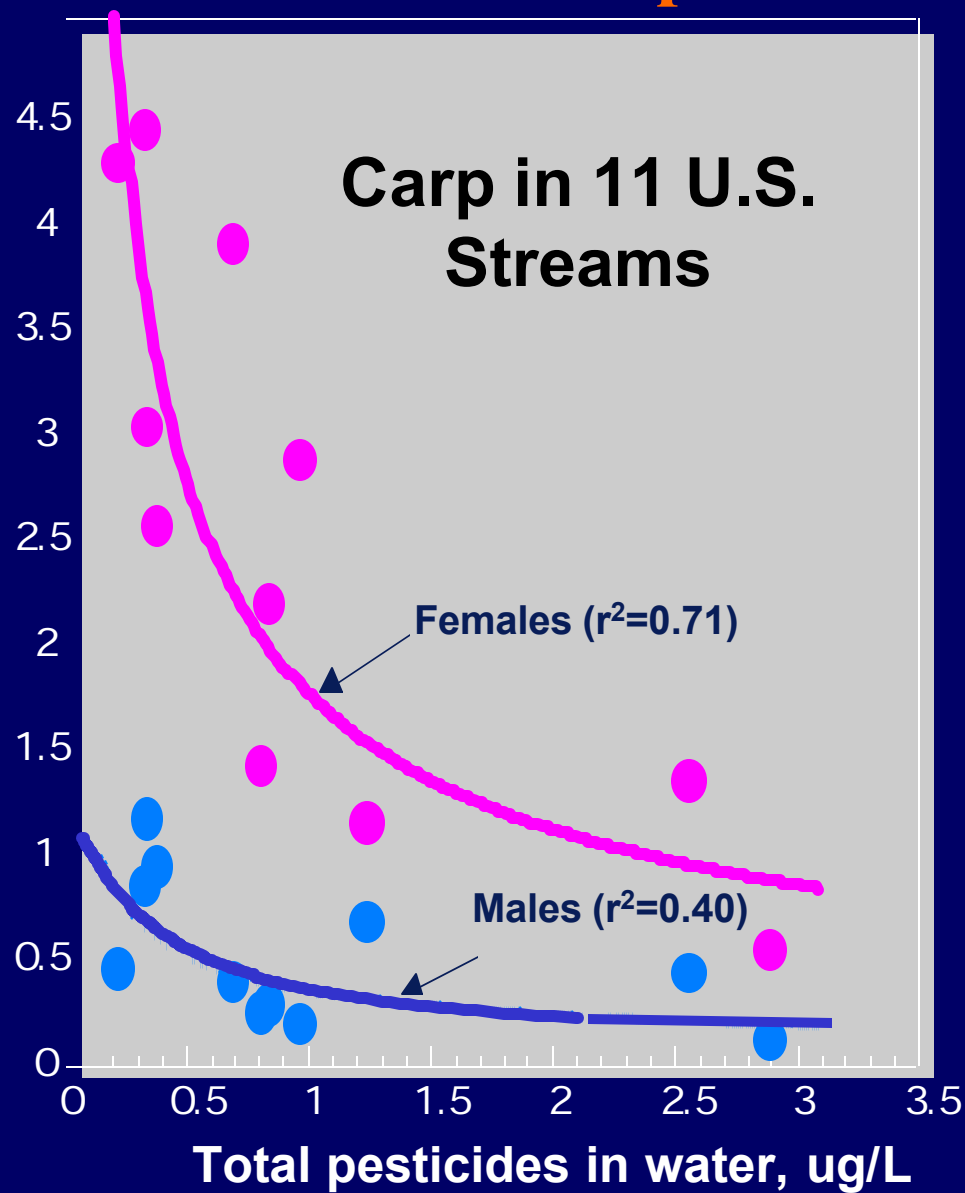


# Agriculture vs Urban

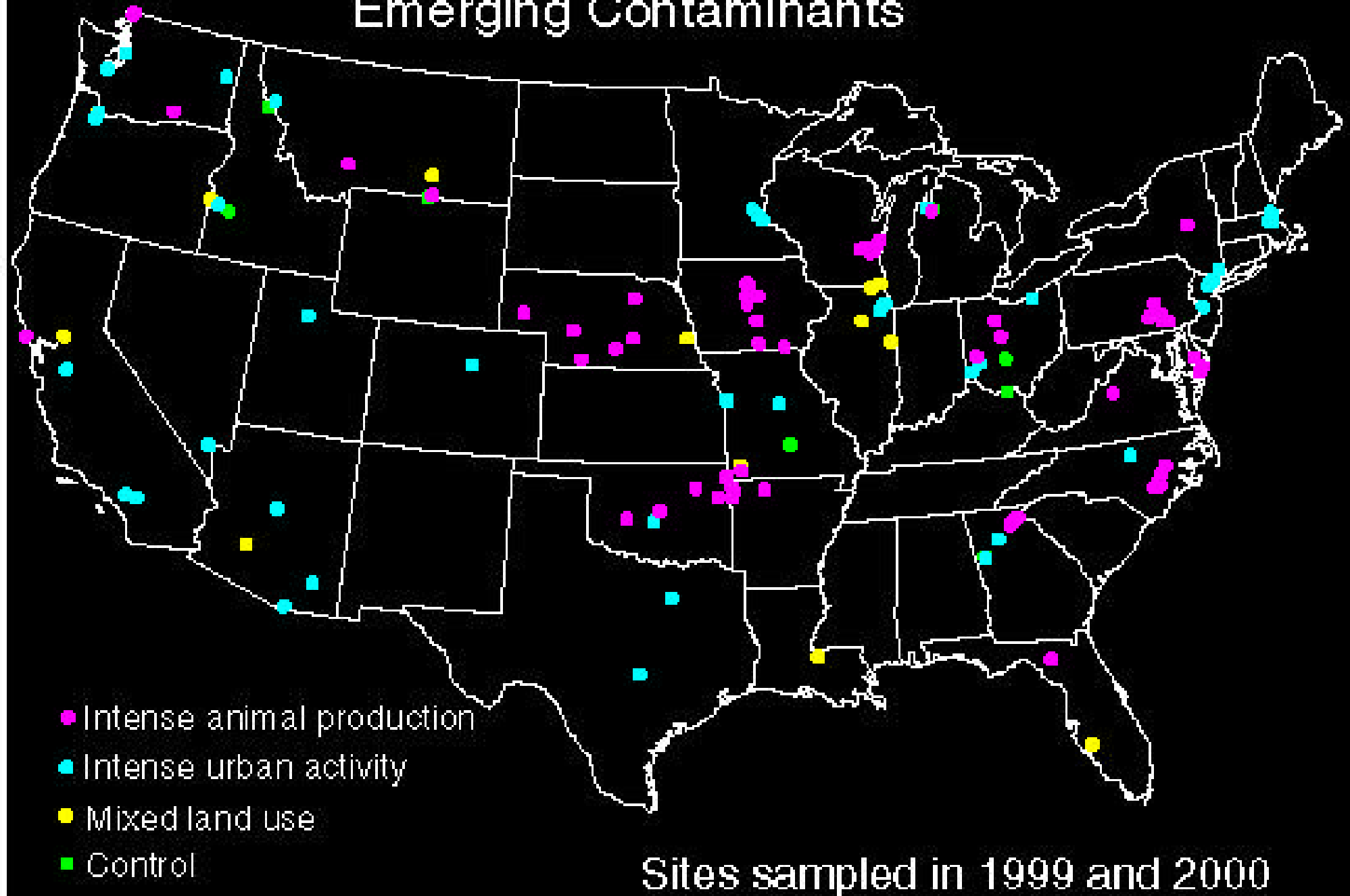


# Reconnaissance Data Show Potential for Endocrine Disruption

Estrogen  
Testosterone



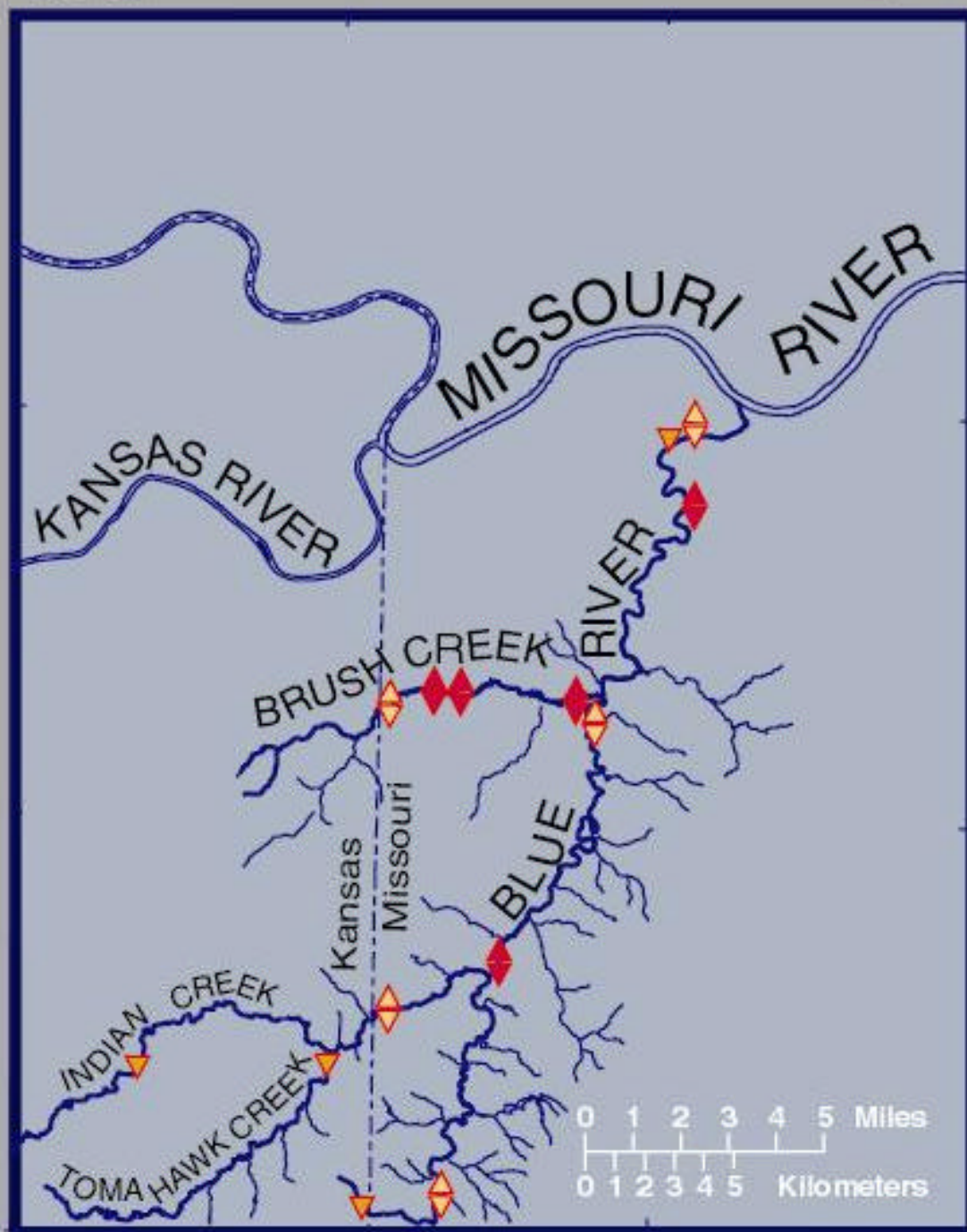
# Stream Reconnaissance Network for Emerging Contaminants






94° 52' 30"

94° 30' 00"

39° 15' 00"



-  Continuous record water-quality site and gaging station
-  Sampling site and gaging station
-  Sewage treatment plant




38° 52' 30"



**Extensive capital  
improvements**

**\$200 M Public  
\$630 M Private  
Flood control  
Recreation  
Business Development**



A photograph of a city waterway, likely a canal or river, with concrete walls on both sides. The water is dark and reflects the surrounding urban environment. In the background, a bridge spans the water, and various city buildings are visible under a clear blue sky. The water appears somewhat stagnant, with some green algae or debris visible along the concrete walls.

**WQ concerns related  
~200 CSO inflow  
points  
w/in  
study area**

**“la Grande Gargouille ”**

It's the only water we got in this town that's flowing through other than pipes, and to me it's good just to see that. It's sort of like I associate that with life. And Blacks Run is pretty visible everywhere that you look. And it's part of our downtown and we need to treat it as such. --Rodney Eagle



Scott Jost. *Blacks Run An American Stream*;  
Center for American Places, 1999

I'm not kidding when I say we should put a skull and crossbones up. I don't think the average person in Harrisonburg has any idea how polluted the water is.

--*Susan Mansfield*

Scott Jost. *Blacks Run An American Stream*; Center for American Places, 1999



It's the only flow of water through town that takes the water out of here in floods. If you wouldn't have that, this would be a swamp --*Bill Jordan*



**Scott Jost. *Blacks Run An American Stream*; Center for American Places, 1999**

# Objectives

- Determine conc. & loads for selected contaminants associated with sewage overflows during base and storm flows
- Identify critical stream areas affected by CSOs
- Examine CSO impacts on 3 Brush Creek impoundments

## Approach (cont.)

- New wastewater methodology being used to sample for:
  - Bisphenol A (food packaging cmpds)
  - Cholesterol, Coprostanol
  - 17- $\beta$ -estradiol
  - Detergent metabolites
  - Caffeine, disinfectants, fragrances

# Approach (cont.)

- Nutrients
- Suspended sediment
- TOC, COD, CL, BOD<sub>5</sub>
- Selected Pharmaceutical compounds
  - Acetaminophen, Ibuprofen
  - Diltiazem (anti-hypertension)
  - Sulfamethoxazole, Trimethprim (Antibacterial)
  - Cimetidine (antacid)

# Approach (cont.)

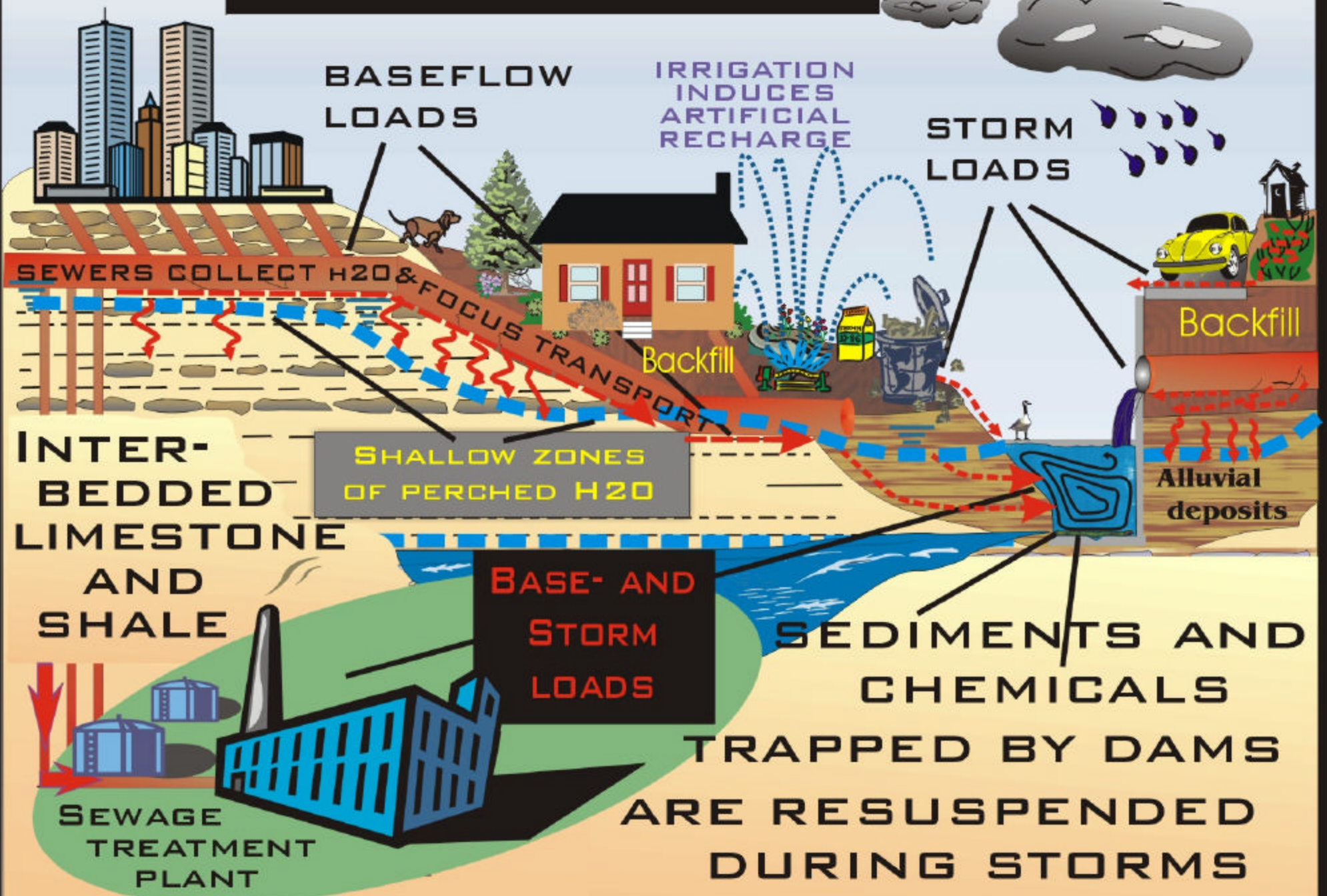
- Base flow sampling  
(x6 annually)
  - 7 surface sites
  - 3 sewage influent streams
- Continuous Q @ 7 sites
- Continuous WQ @ 5 sites
- Sample 4-5 storms  
annually
- Segmented storm  
sampling
- Flow-composite storm samples using TINY BASIC programs



## Emerging contaminants

C. Hignite and D.L. Azarnoff, 1977,  
Drugs and drug metabolites as  
environmental contaminants, Life Sciences,  
v. 20, pp. 337-342.

# CONCEPTUAL FLOW MODEL



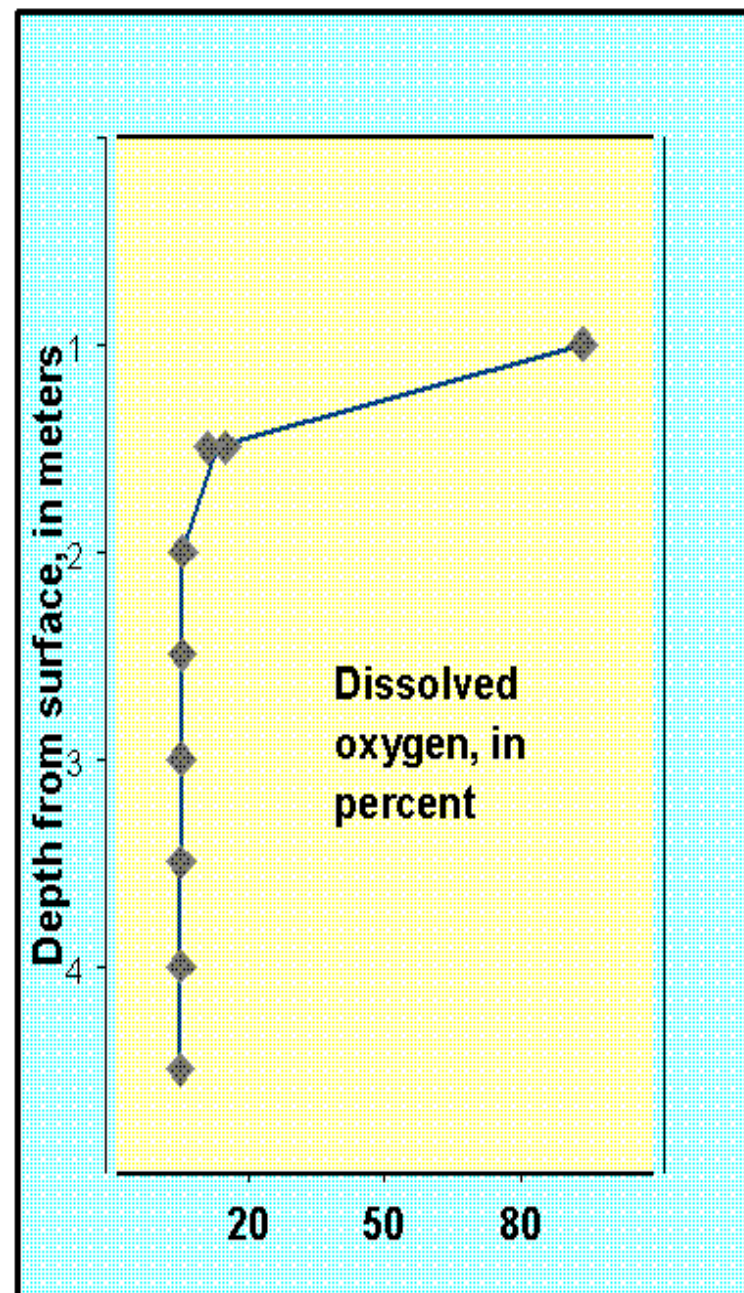
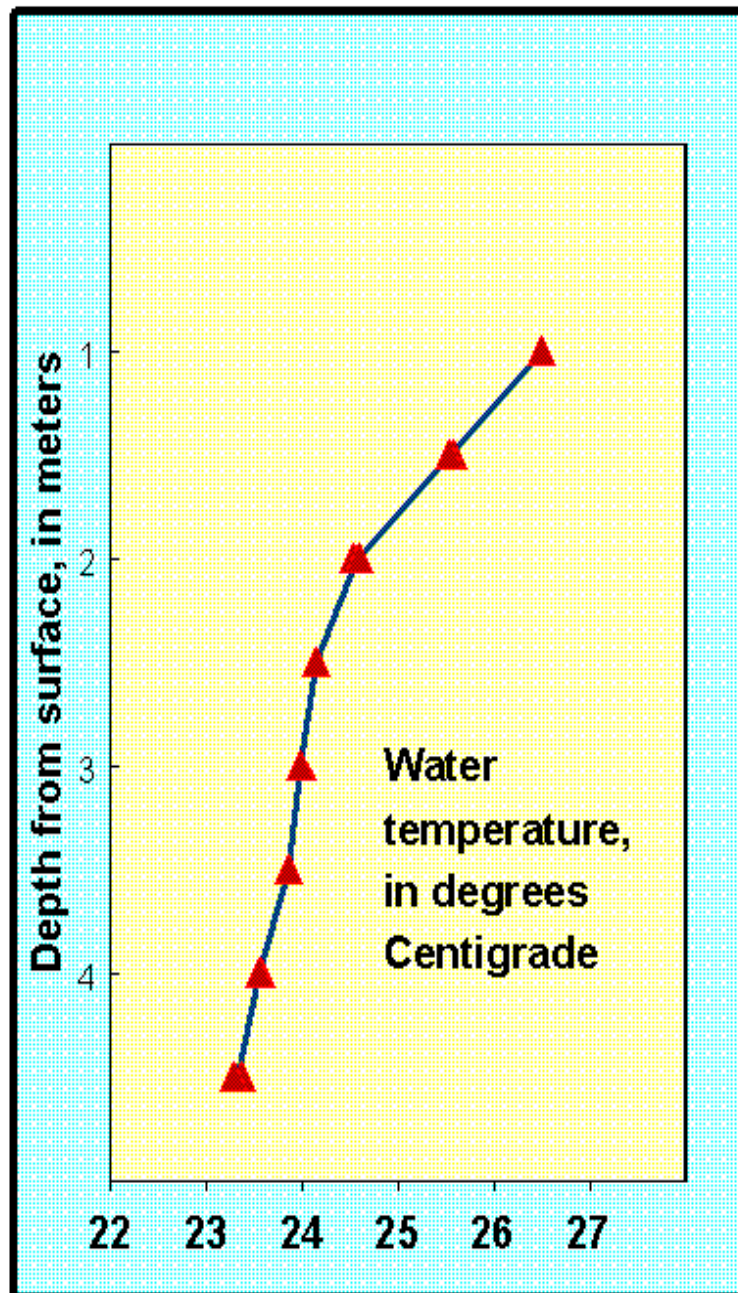


Storms deposit sediments

These sediments  
may provide a  
continuous source of  
contaminants during  
baseflow



# Brush Creek @ Elmwood Ave. Profile



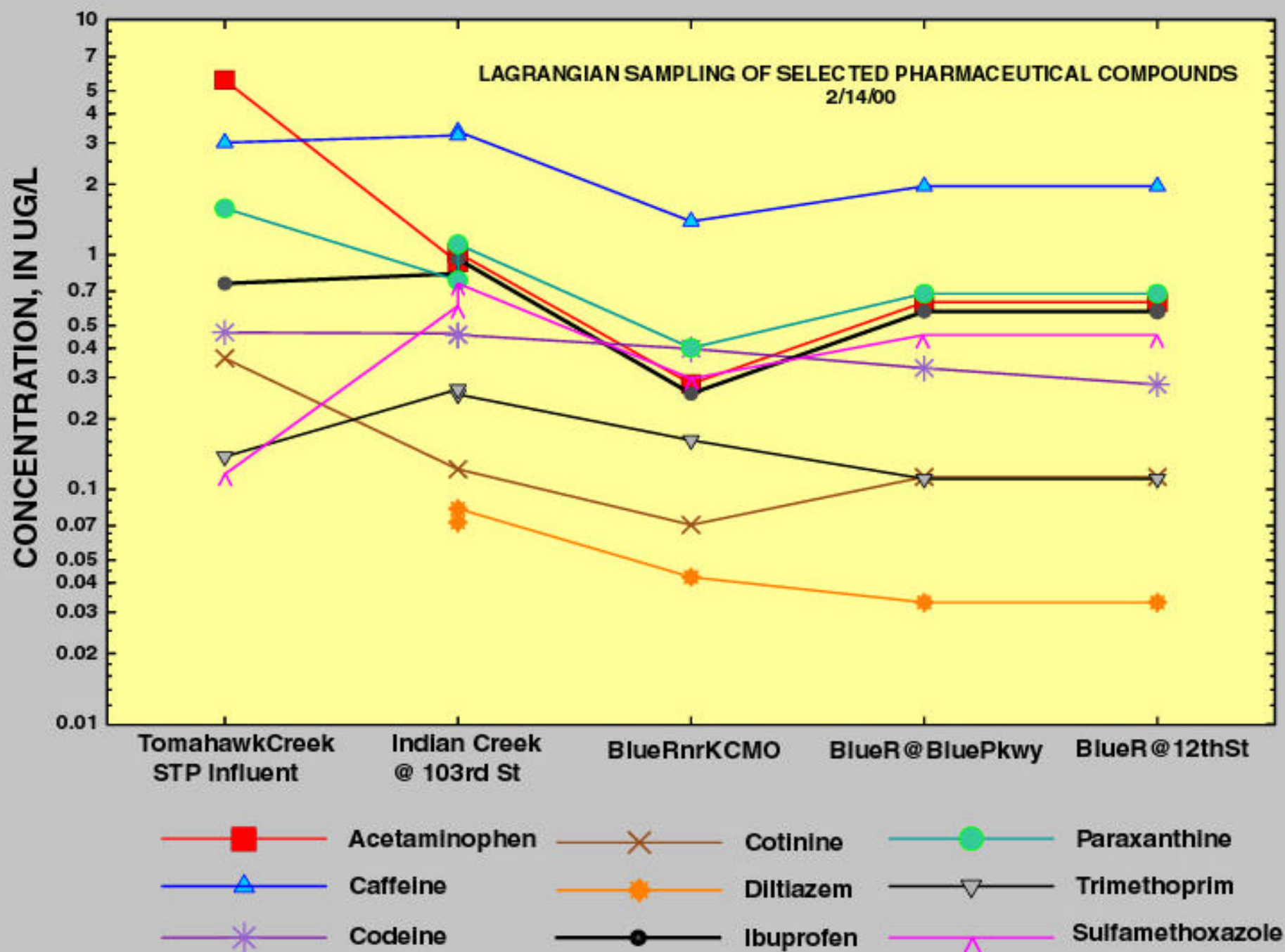
# Frequency of drug detections

- **DETECTED DRUGS**

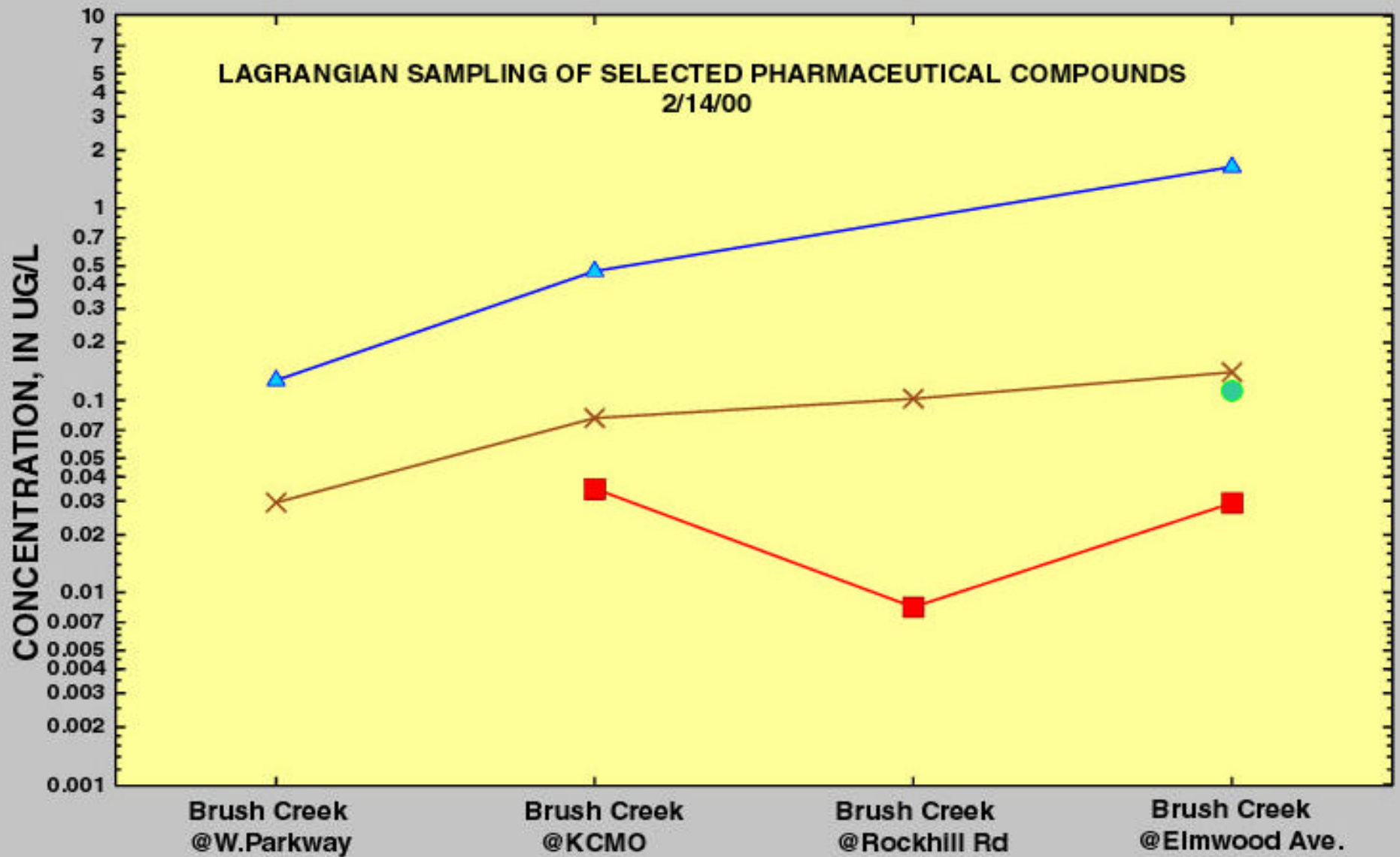
- Acetaminophen - 80%
- Caffeine - 67%
- Codeine - 47%
- Cotinine - 87%
- Diltiazem - 40%
- Gemfibrozil - 6.7%
- Ibuprofen - 40%
- Paraxanthine - 60%
- Sulfamethazole - 53%
- Trimethoprim - 67%

- **NO DETECTIONS**

- Digoxin
- Cimetidine
- Enalaprilat
- Fluoxetine
- Furosemide
- Lisinopril
- Metformin
- Salbutamol
- Ranitidine
- Warfarin



LAGRANGIAN SAMPLING OF SELECTED PHARMACEUTICAL COMPOUNDS  
2/14/00

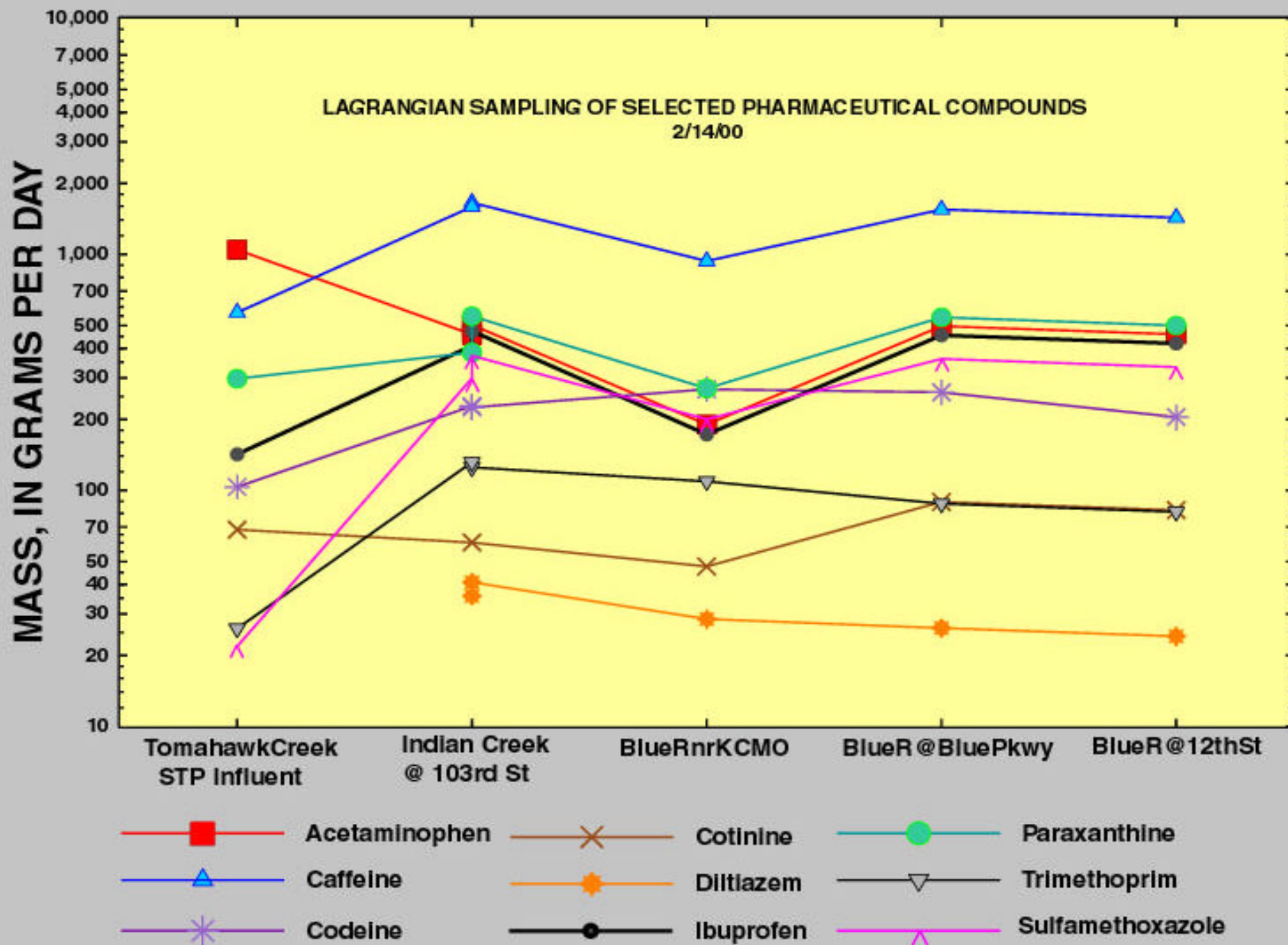


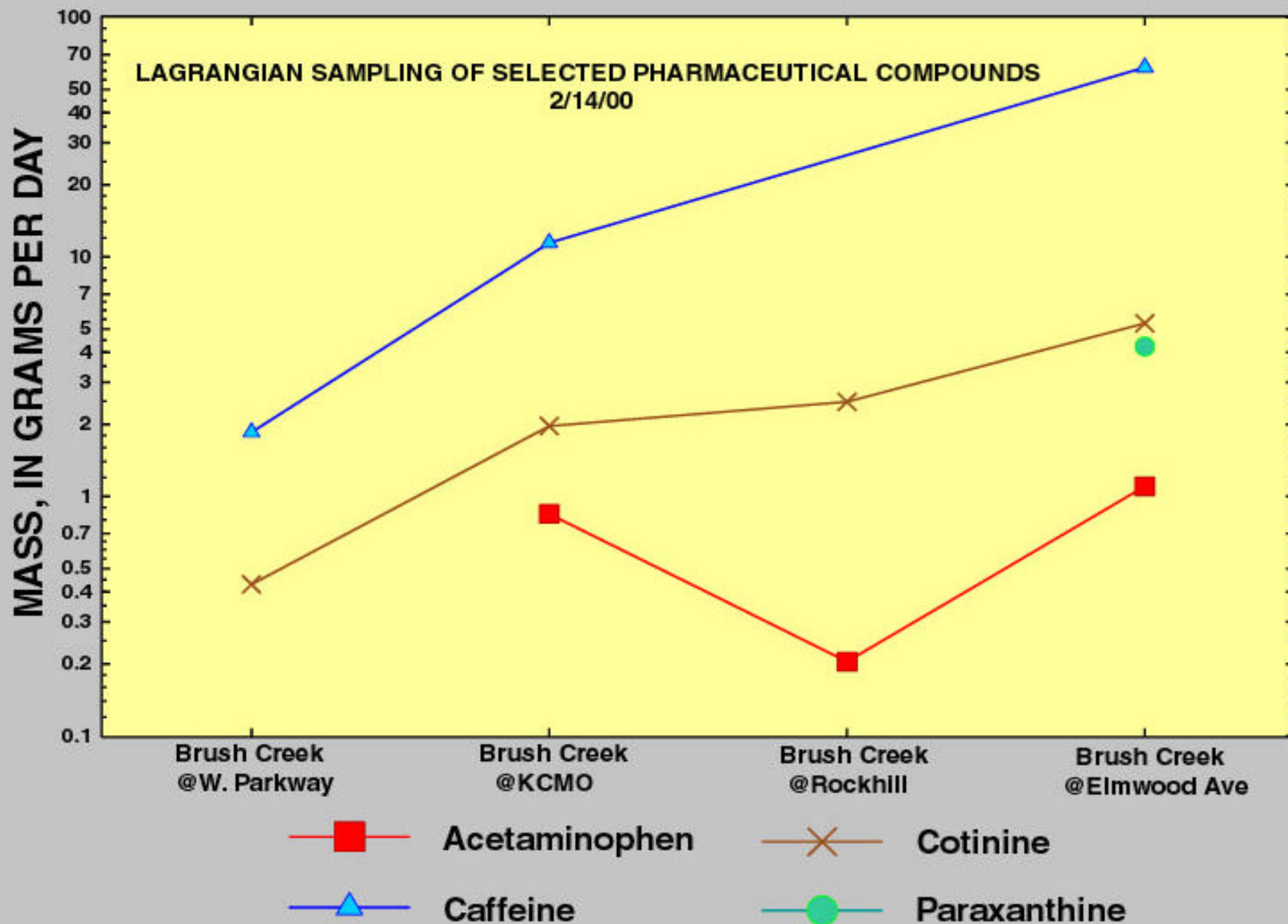
—■— Acetaminophen

—×— Cotinine

—▲— Caffeine

—●— Paraxanthine





## HOW MANY PEOPLE?

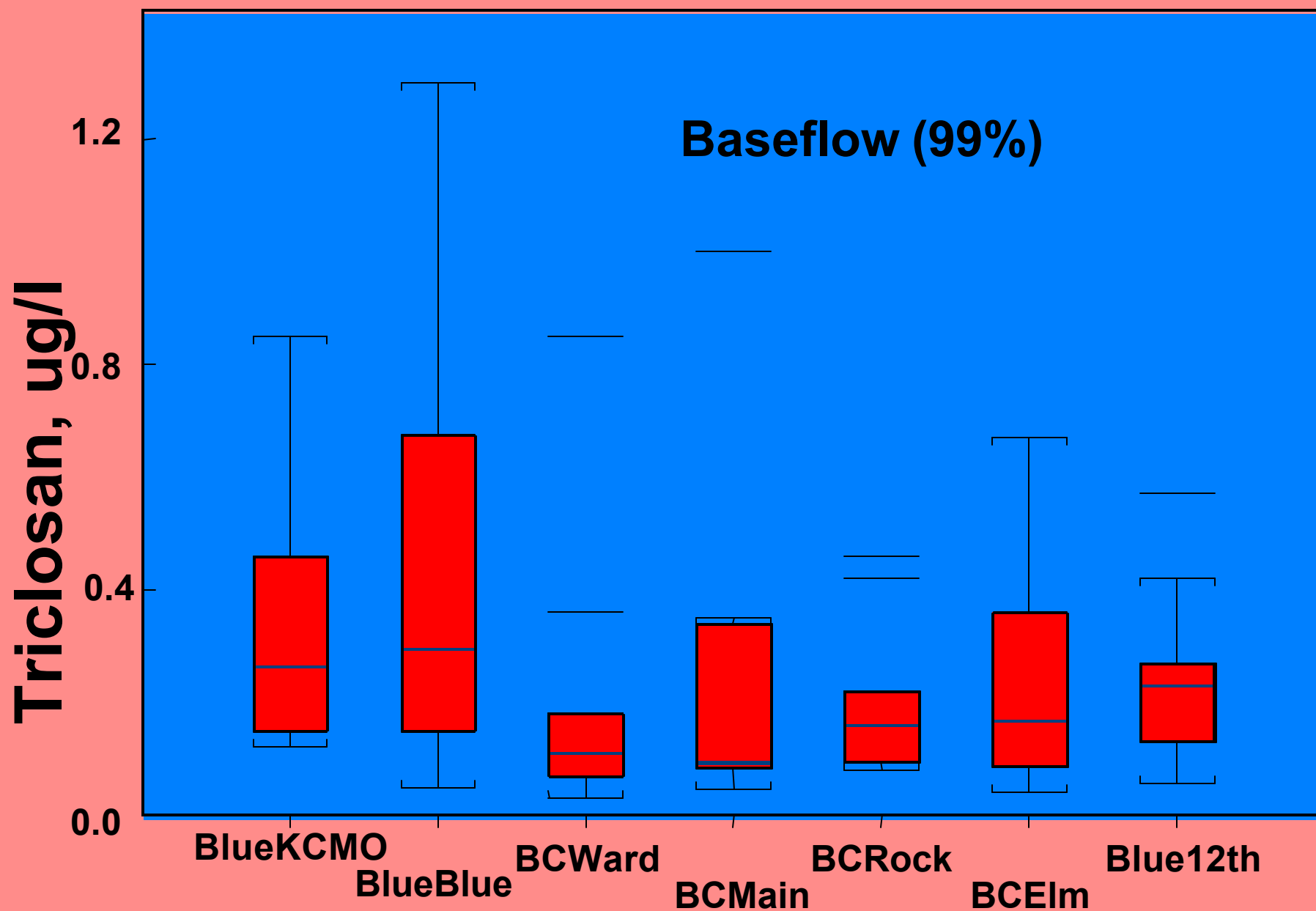
$$\frac{\text{CALCULATED DAILY MASS}}{\text{PRESCRIBED DAILY DOSEAGE}} \times \text{PERCENT LOSS}$$

<u>SOURCE</u>	<u>AVERAGE # OF PEOPLE</u>
STP INFLUENT	4450
INDIAN CREEK/ BLUE RIVER	2130
BRUSH CREEK	40

STP effluent >> GW contributions

**upstream**

**downstream**



**upstream**

**downstream**



**Stormflow (98%)**

**Triclosan, ug/l**

0.5  
0.4  
0.3  
0.2  
0.1  
0.0

**BlueKCMO**

**BlueBlue**

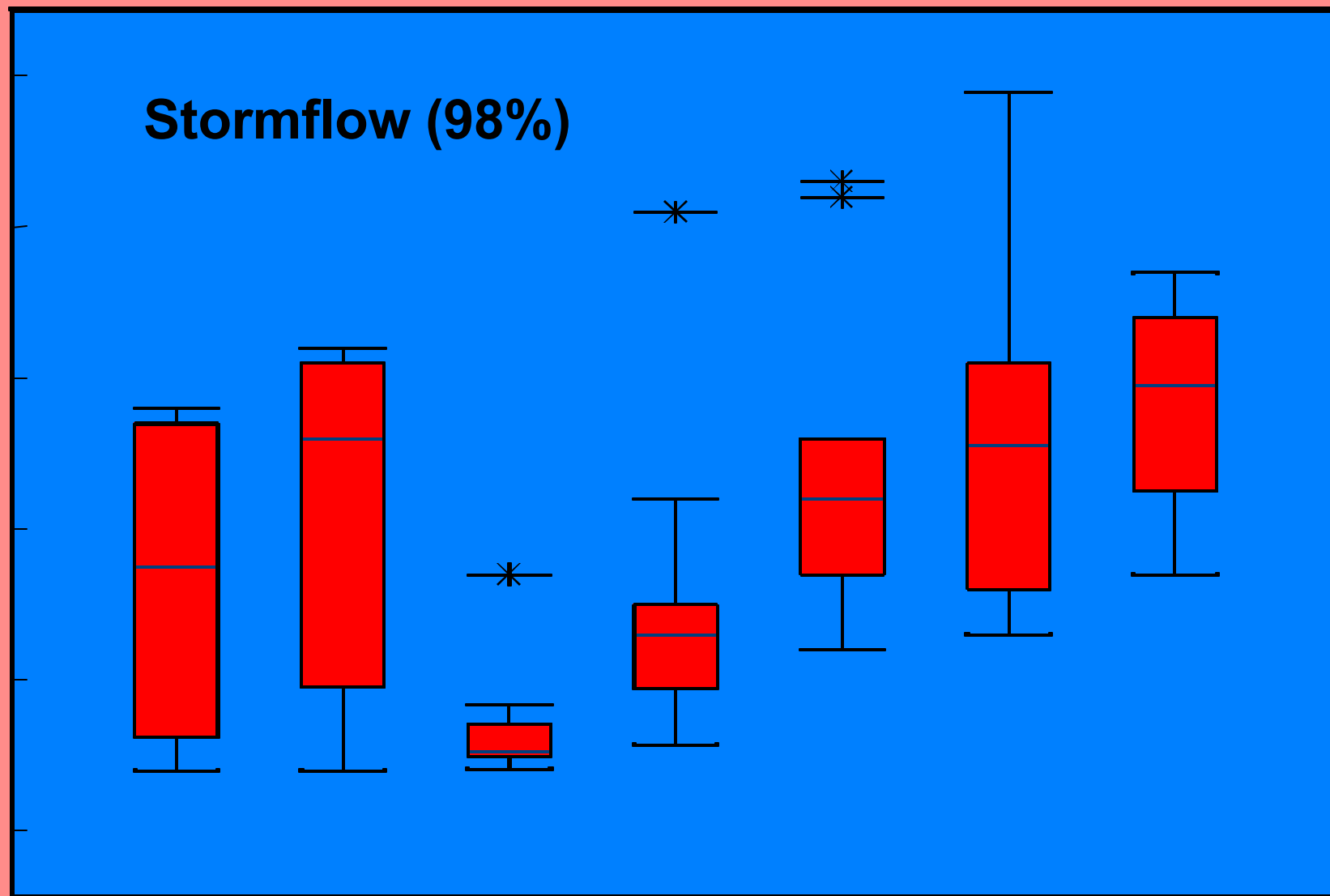
**BCWard**

**BCMain**

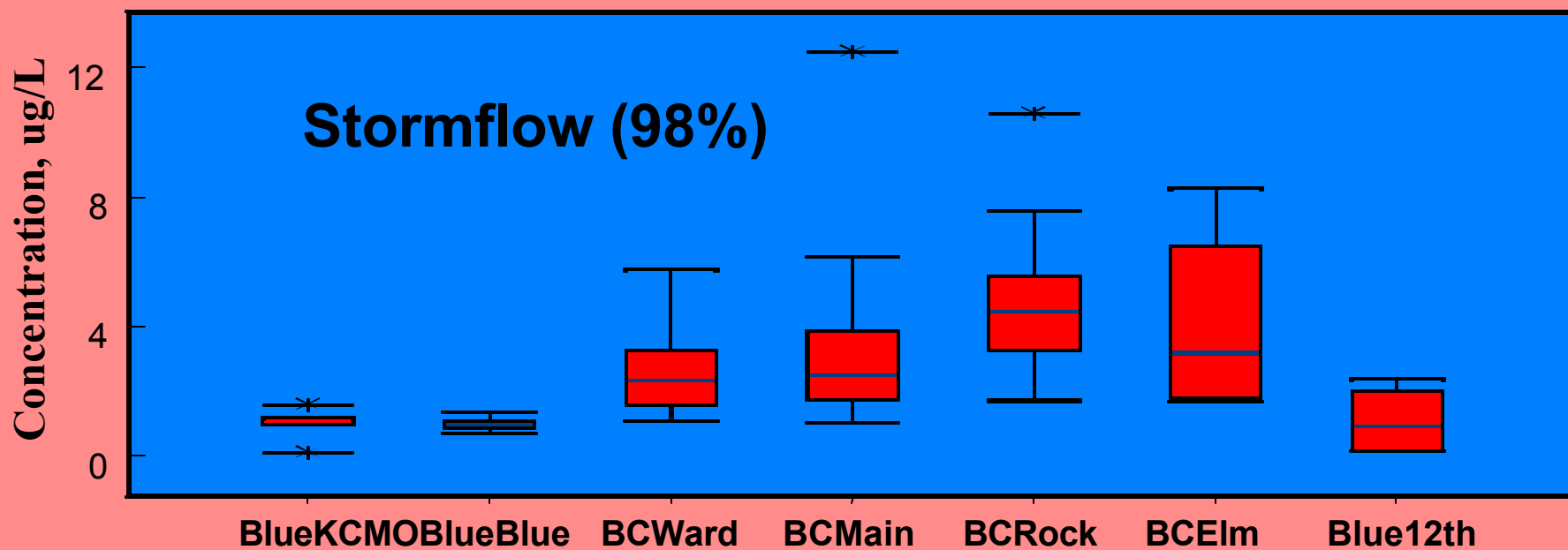
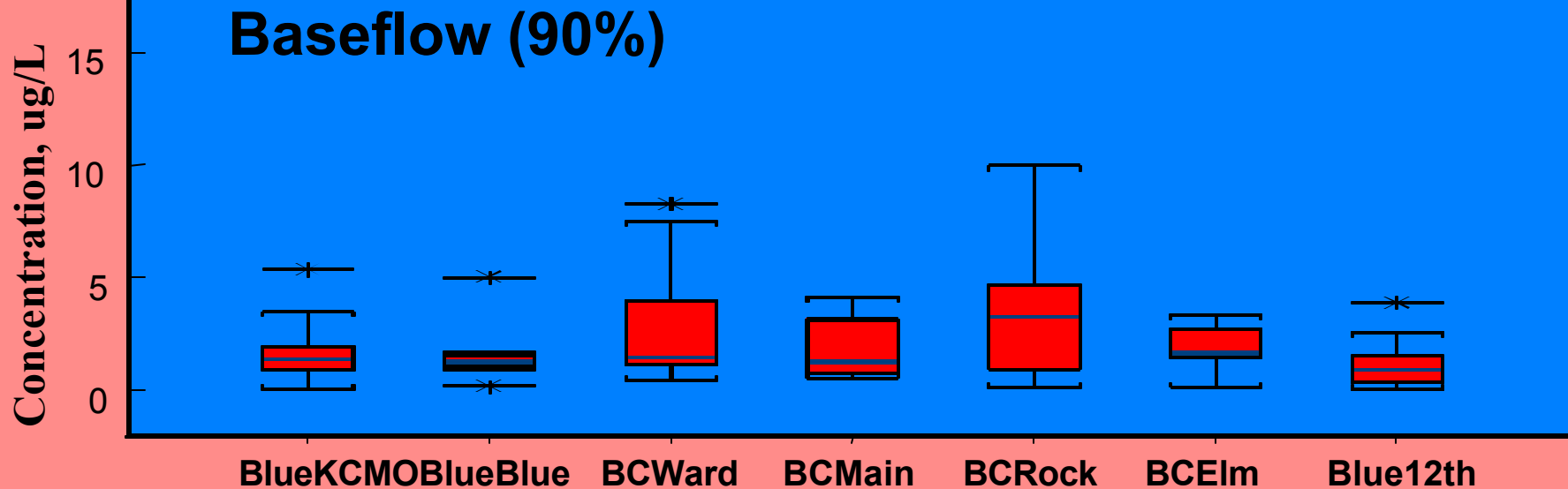
**BCRock**

**BCEIm**

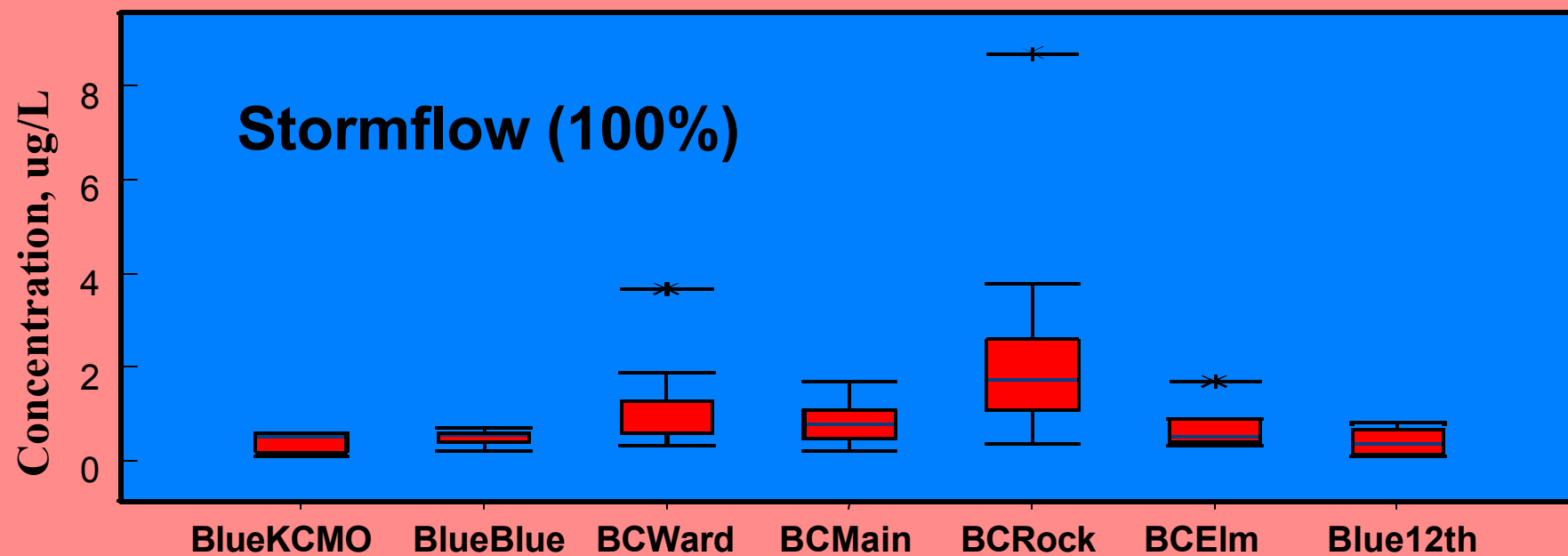
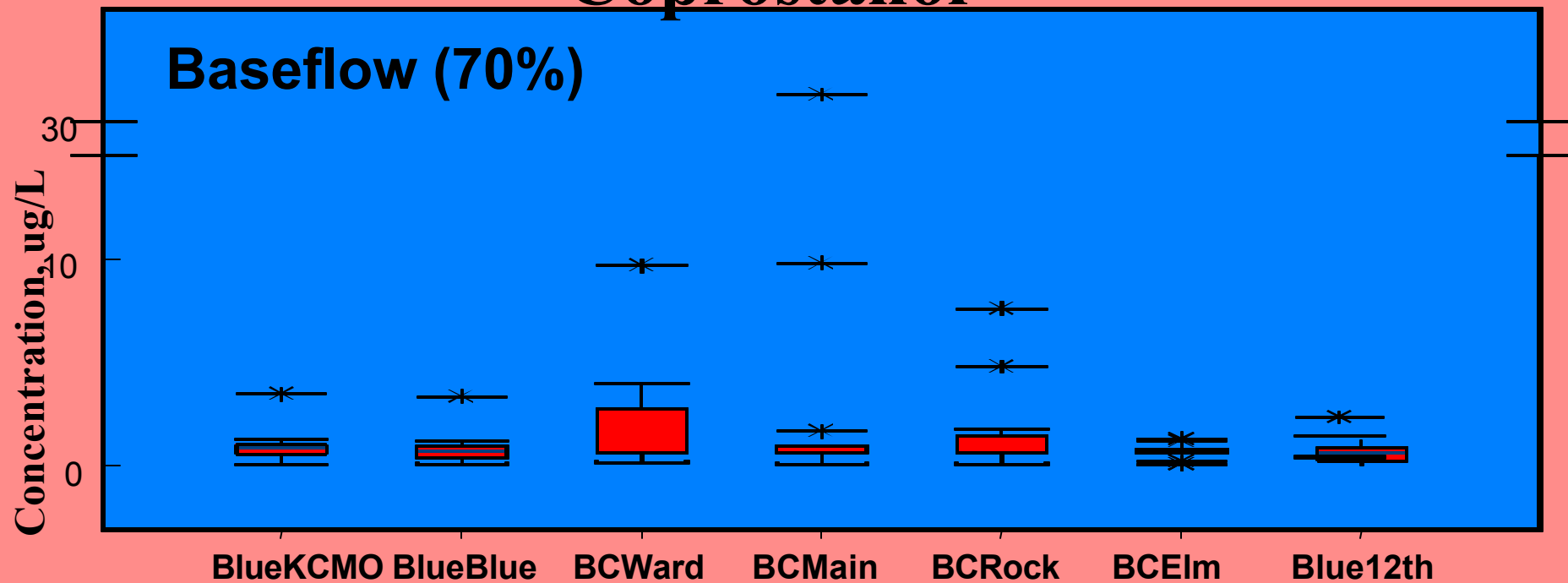
**Blue12th**



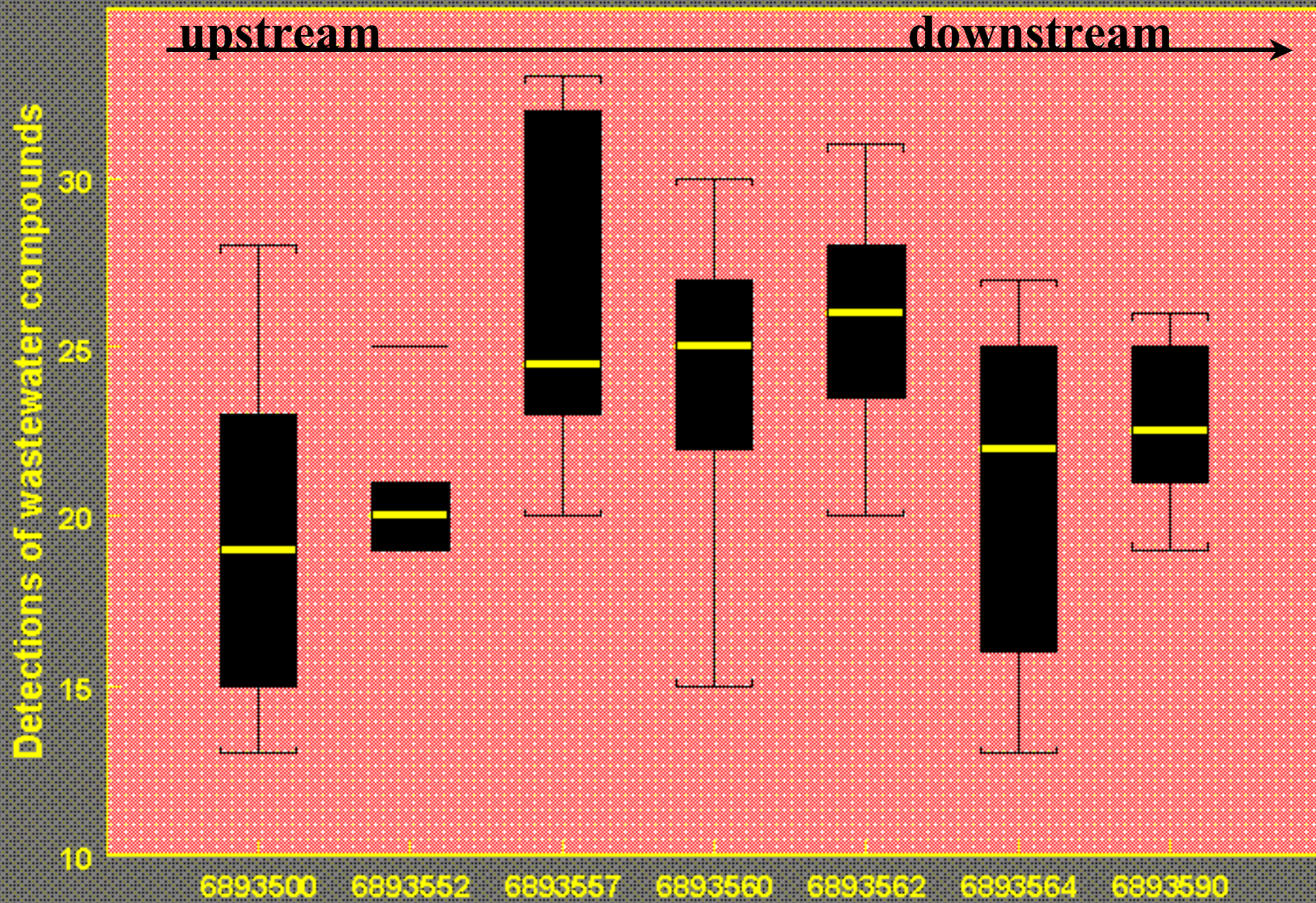
# Cholesterol



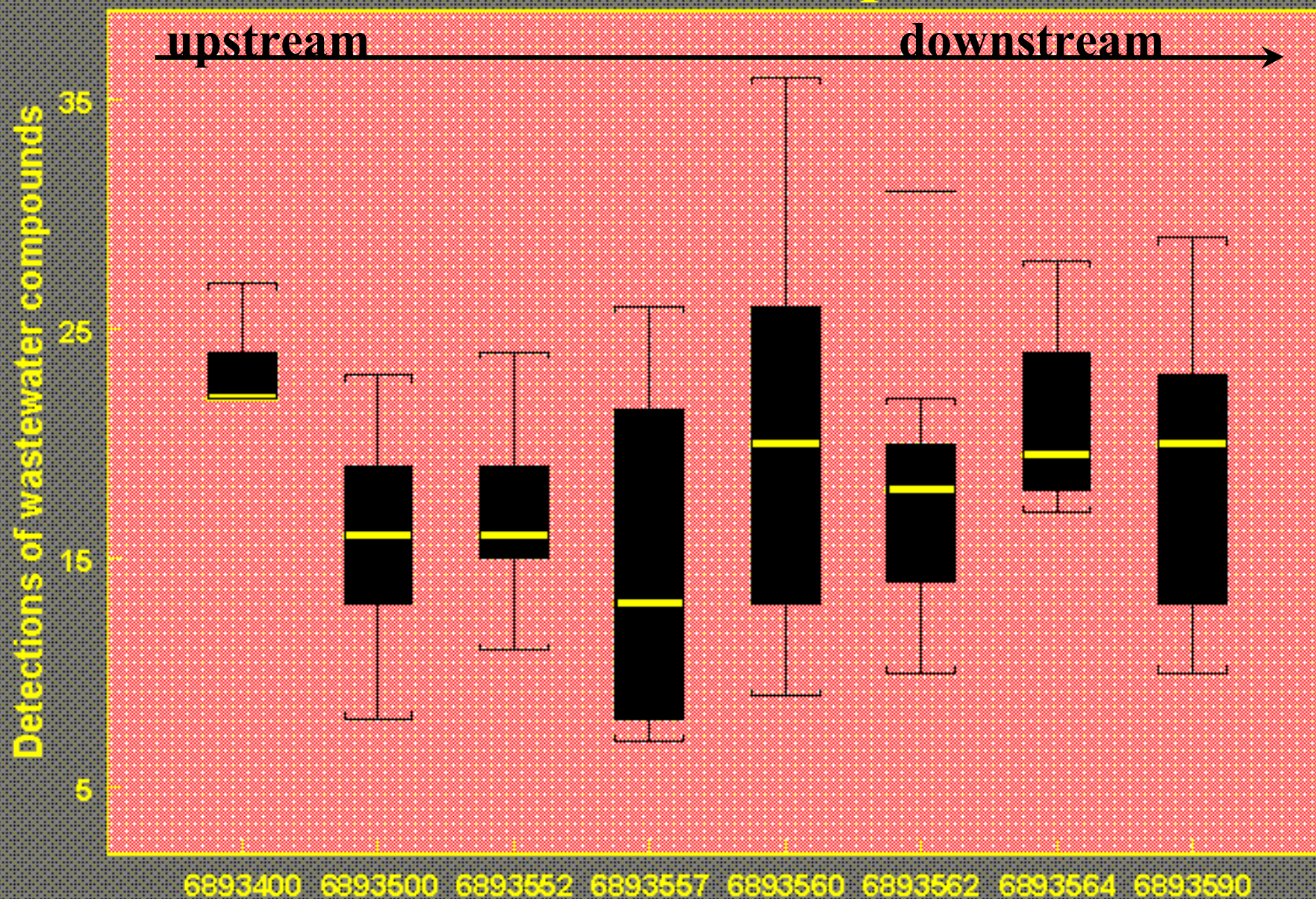
# Coprostanol



# Storm samples



# Baseflow samples

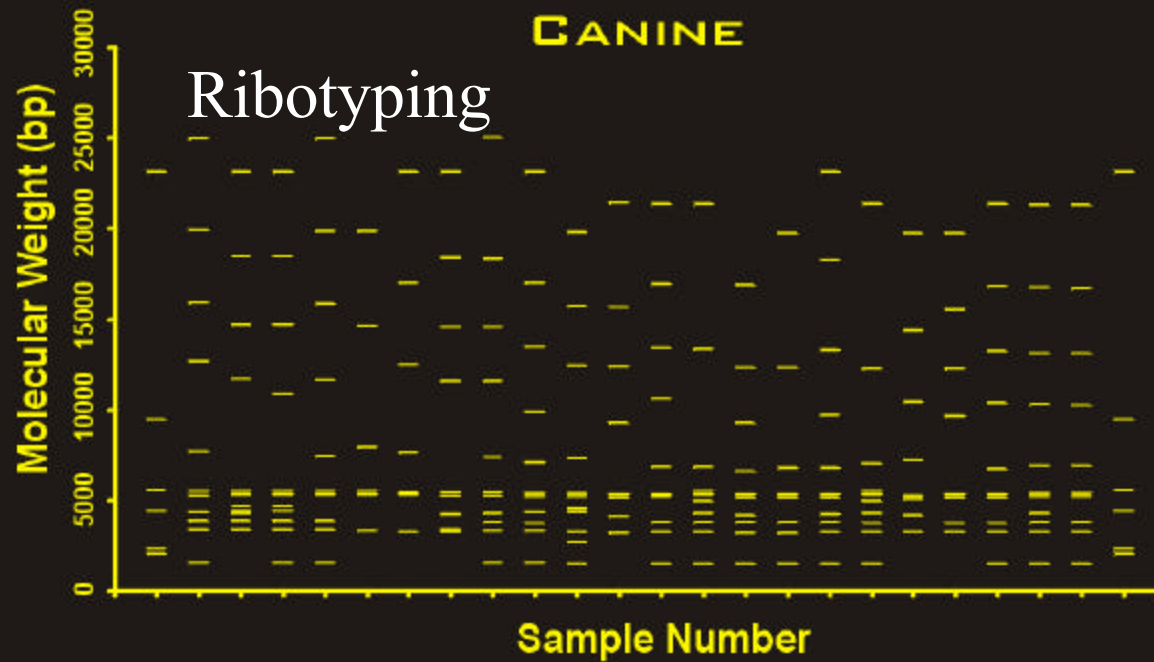
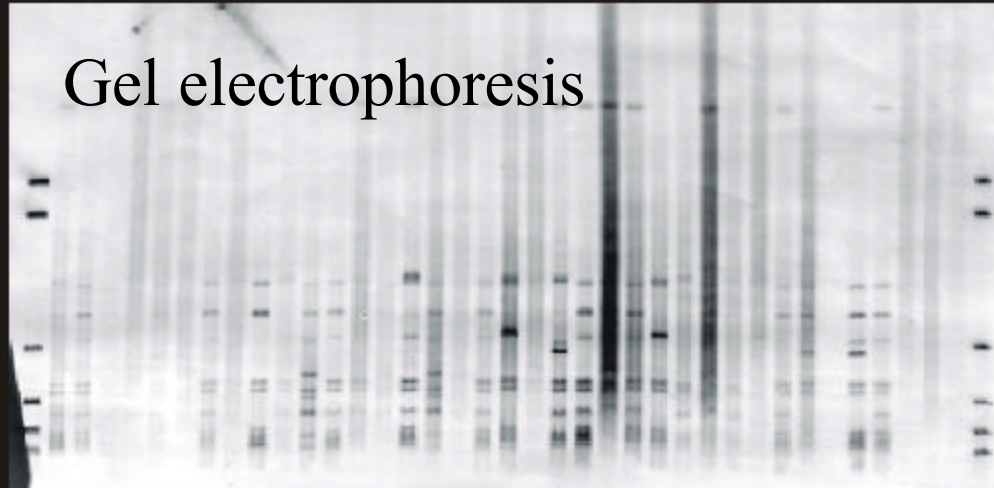


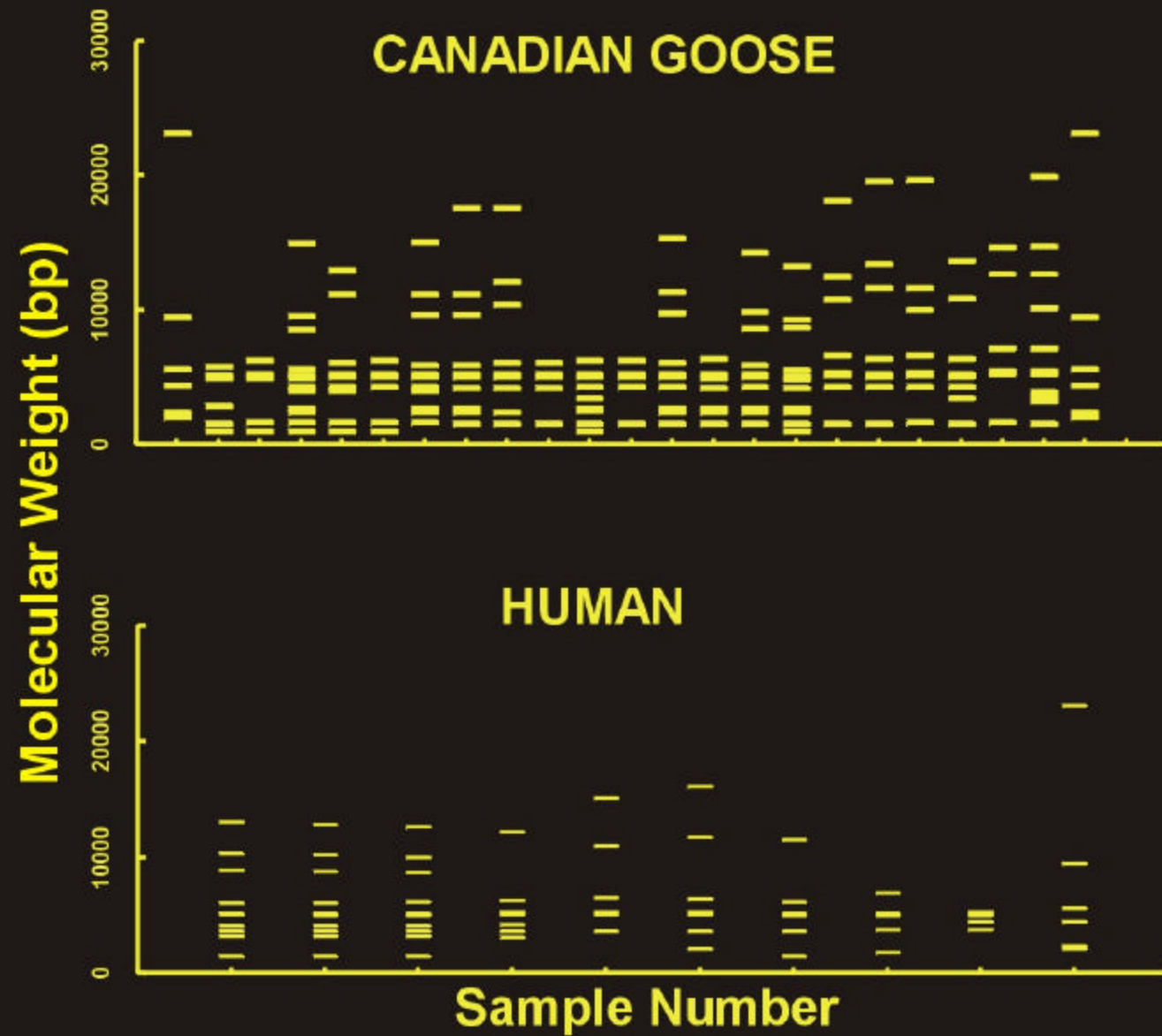
# **BACTERIAL SOURCE TRACKING**

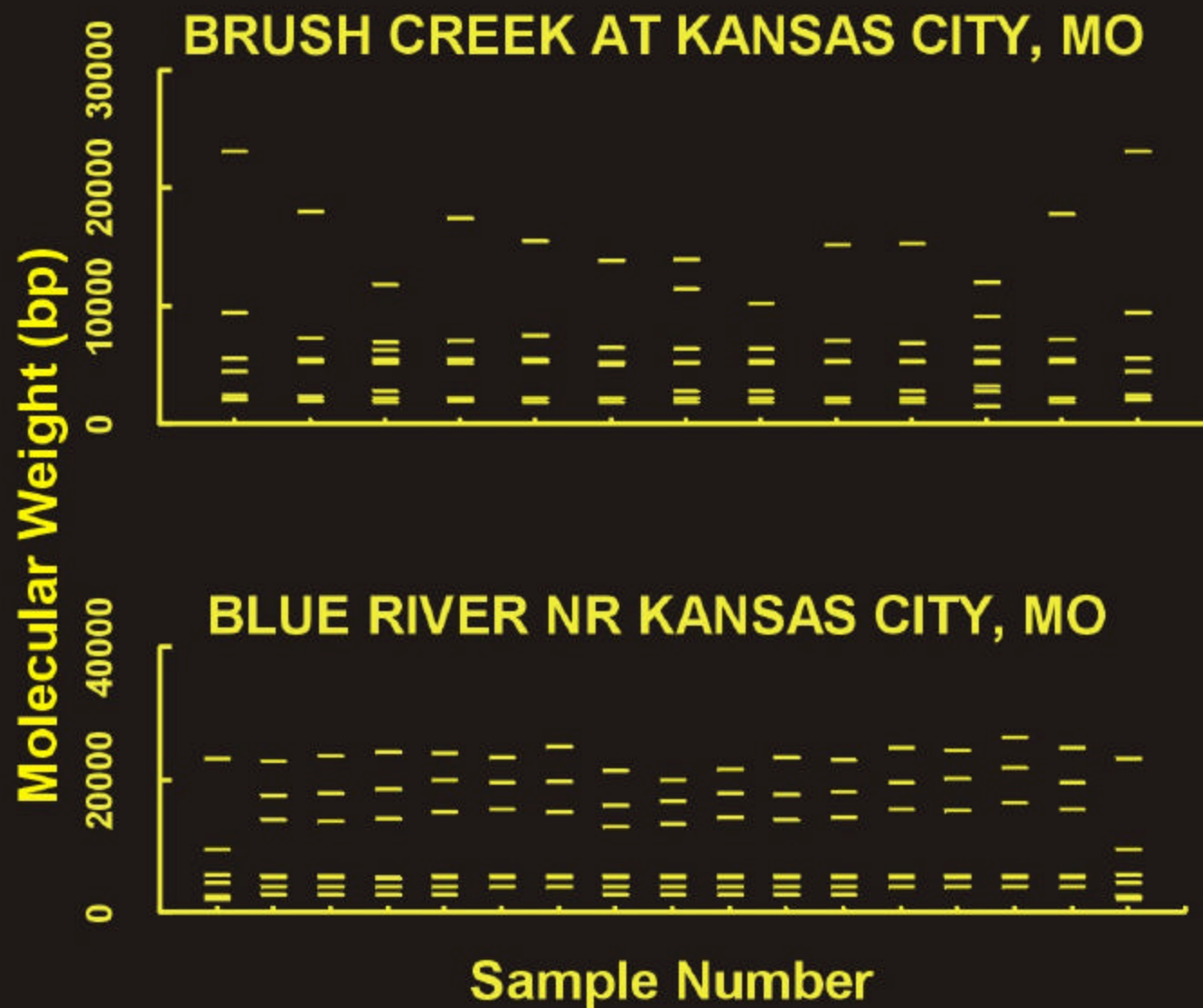
- **Currently under development**
- **Andy Carson, U. of Missouri  
(Veterinary Pathobiology)**
- **Wide application**
  - Jack's Fork (Horse/human?)
  - Shoal Creek (CAFO's/Poultry?)
  - Little Sac River (STP/Cows?)
  - Longbranch Reservoir  
(Humans/Hogs/Geese?)
  - Kansas City (Humans/Dogs/Geese?)

## E. Coli source tracking using:

Gel electrophoresis







# **SOURCE TRACKING PROCESS**

- **Develop source patterns and key markers**

- **Isolate patterns from water samples**



- **Refine statistical program for identification**

# Conclusions

- Detections of pharmaceuticals & wastewater compounds common in urban streams
  - Baseflow
  - Stormflow
- Concentrations are low/effects unknown
- Urban environment has many sources
- Source characterization difficult

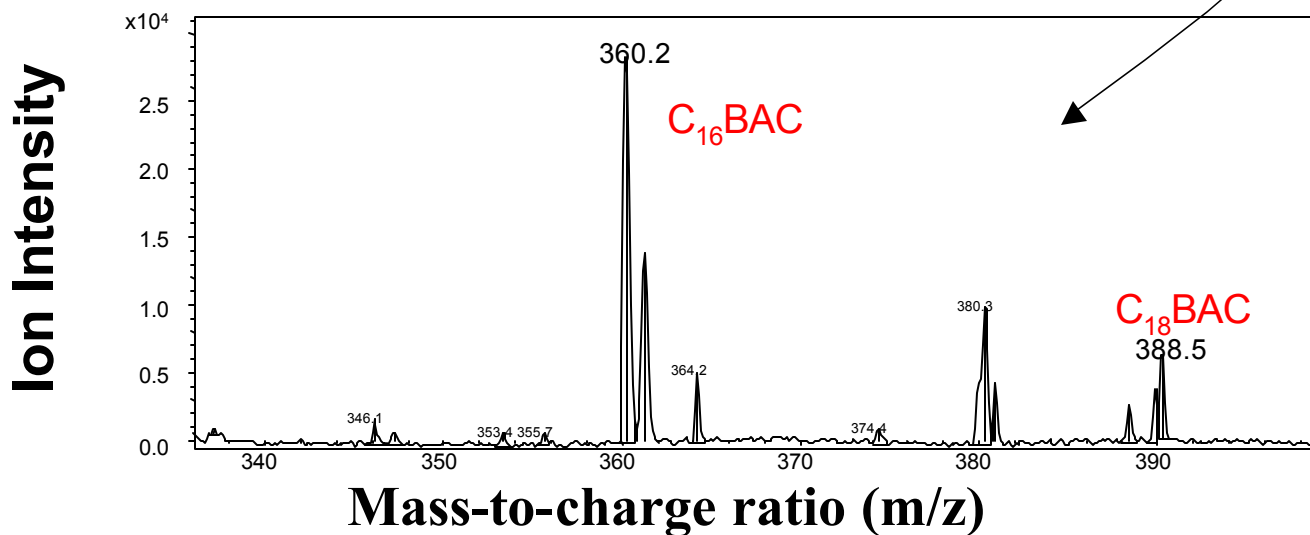
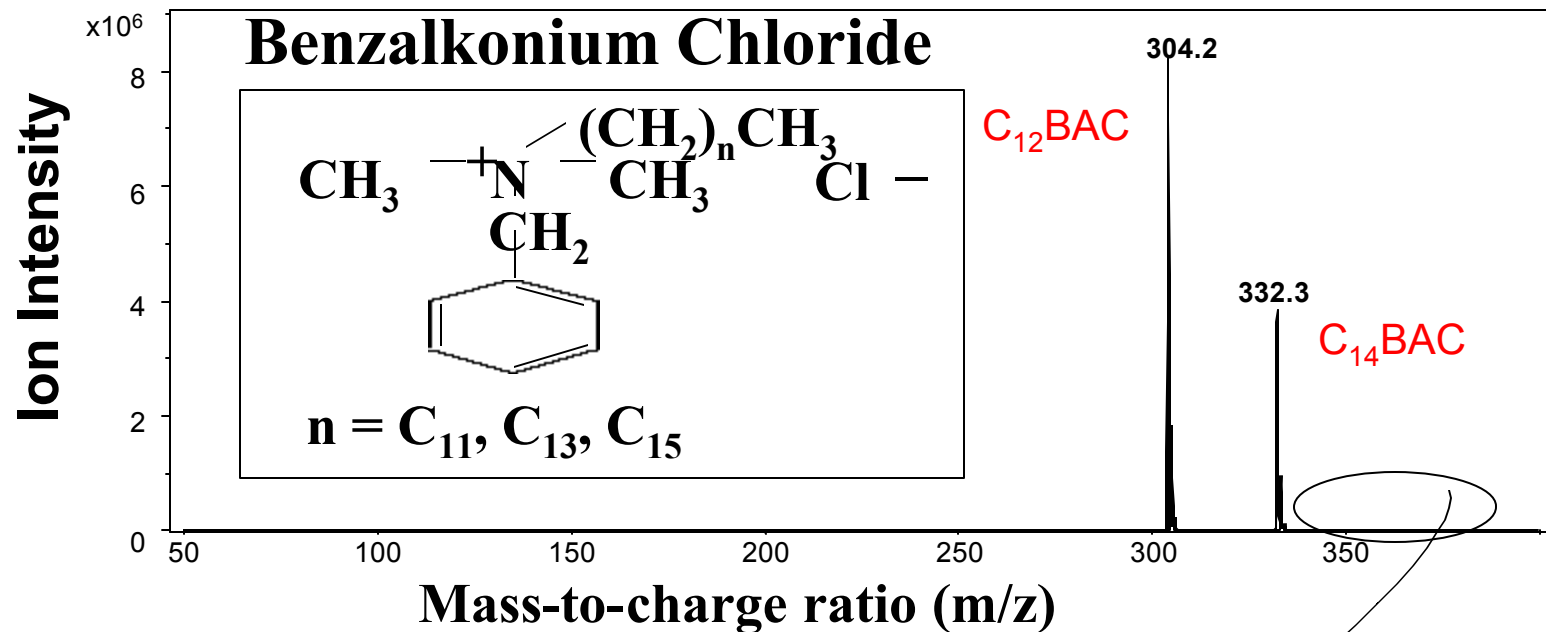
## Conclusions (cont.)

- Sediments may provide continued source of contaminants
- Pharmaceuticals/ratios as tools of understanding
- STP effluent >> GW contributions

# Punditry – what does it mean?

- Gore – interesting, complex idea that demands further study; Have you looked at my prescription drug plan?
- Bush – Is anybody dying?; Have you looked at my prescription drug plan?
- Nader – There are 30 M children in the country w/o health care and you're worried about drugs in the environment!
- Buchanan – Let's let the drug companies regulate their own business.

# Is this truly the age of analytical chemistry?





**Our grasp on  
the environment is  
tenuous**



# IMPLICATIONS

**FOCUS ON  
ENVIRONMENTAL  
ISSUES**

**FOCUS ON  
HEALTH & SAFETY  
ISSUES**



# **What are the appropriate toxicological methods?**

- **Are they already in place?**
  - **Dose-response measures (anthrocentric)**
- **Ecosystem based measures**
  - **Indices of macro-invertebrates?, fish?, plants?**
  - **Also dose-response measures**
  - **Surrogates (point?; Lagragian?; integrated?)**
- **Toxicity assays (acute, or chronic?)**
- **Other methods?**

